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*Shelve in Stacks S.D.T.*

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U.S. SUPT. OF DOCS.

A CONTRIBUTION TO THE STUDY OF ANALOGUES  
OF POWER TRANSMISSION IN MACHINES

It is today 35 years after the founding of the "German Democratic Republic" and the country has achieved great success. The German Democratic Republic has already made a number of important contributions to the development of the German Democratic Republic. The German Democratic Republic has already made a number of important contributions to the development of the German Democratic Republic. The German Democratic Republic has already made a number of important contributions to the development of the German Democratic Republic.

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## ABSTRACT CITATIONS

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## FINAL REPORT TO THE LEGISLATURE OF THE STATE OF CALIFORNIA [THE DRINKING DRIVER]

An attempt is made, in response to recommendations made by the governor of California regarding drunken driving, to determine the following: whether it is possible to classify individual drivers into drinker subtypes that correspond to the nature and extent of the individual's drinking problems; who is best suited to perform such a classification; and whether diagnostic classification results in a more effective tailored treatment rehabilitation of problem behavior as measured by driving record information. These questions were evaluated by reviewing the current literature relating to countermeasures and the drinking driver, and by conducting a series of specially designed research studies relating to the drinking driver. Past research attempts at classifying the drinking driver are reviewed. The three data sources for classification (alcohol-related arrest data based on driving and criminal record, blood alcohol concentration, (BAC), and psychometric tests) are discussed. In an attempt to maximize the predictive value of available objective information, the following models combining the information have been constructed: the University of Southern California model (stressing certain characteristics which differentiate drinking drivers from others, and recidivist drinking drivers from non-recidivists); and the Alcohol Safety Action Project (ASAP) effort (some success in discriminating between recidivist and non-recidivist populations but not as reliable on an individual prediction basis). The feasibility of having county medical advisory boards classify drinking drivers is discussed with reference to ASAP experience. Studies of the effectiveness of various drunken driving countermeasures (ASAP, Alcoholics Anonymous, films and lectures, alcoholic rehabilitation centers, group therapy, conventional punitive sanctions, and alcohol safety schools) are discussed. Data is presented on the effectiveness of the ASAP systems concept as a whole. It is concluded that: BAC, the number of prior drunken driving offenses, and alcohol tests such as the Michigan Alcohol Screening Test and the Mortimer-Filkins which have been validated on driving populations are the best indicators of problem drinking drivers; the medical advisory board concept of classification is not recommended because of the lack of competently trained physicians and the low cost-benefit ratio; classification made by trained non-medical personnel is as effective as that by medical professionals and less expensive; at this point there is no scientifically acceptable evidence to demonstrate that classifying drinking drivers has a beneficial effect on subsequent accidents or drunken driving recidivism, or that customized rehabilitation programs based on such classifications have positive effects; and there is evidence that punitive sanctions have impact on subsequent driving record and deterrent effects on the general driving population.

by William V. Epperson; Richard Harano; Raymond C. Peck  
California Dept. of Motor Vehicles, 2415 First Ave.,  
Sacramento, Calif. 95815  
1975 ; 82p refs  
Prepared in accordance with Resolution Chapter 152--1972  
Legislative Session (California Senate Concurrent Resolution  
44--Harmer).  
Availability: Corporate author

## A CONTRIBUTION TO THE STUDY OF ANALOGIES OF POWER TRANSMISSIONS IN MACHINES

An analogy is described by means of which transmissions can be analyzed and compared. Two important design parameters, force density and effective volume, are used to analyze stationary and moving methods of transmission. This analogy enables the designer to compare transmissions with regard to performance, controllability, size and weight, intensity of loading, and dynamic properties. Transmissions of the rotating-rotating, rotating-translating, and translating-translating types are considered. A beginning is made in the formulation of a relationship between the intensity of loading and wear phenomena. Mechanical, electrical, pneumatic, and hydraulic power transmissions can be compared by means of this analogy, and the selection of a transmission can be made more scientifically.

by W. M. J. Schlosser  
Technische Hogeschool te Eindhoven, Eindhoven, Holland  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n1 p1-9  
Rept. No. 1/74 ; 1974 ; 12p 11refs  
Prepared for presentation at an Ordinary Meeting of the  
Institution of Mechanical Engineers, London, 9 Jan 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

## TURBOCHARGING OF SMALL ENGINES

Current technology of turbochargers for high speed diesel engines is reviewed. Progressively smaller diesel engines have been turbocharged during the last 20 years. Spark-ignition engines remain normally aspirated for most applications, although this may change. Progress has followed the adoption of radial flow turbine using lost-wax cast rotors. Some development problems (bearings, seals, vane vibration, and high temperature materials), manufacturing programs (fixing of turbine wheel to shaft, balancing, and flow testing of turbine housings), techniques of matching turbochargers to diesel engines, control systems, and spark-ignition engine applications are discussed. It is concluded that: current turbocharger performance and durability are more than adequate for the most advanced engines of the present day; taking into account existing and proposed legislation regarding emissions, noise, size and power/weight ratio, the highly turbocharged diesel will propel all Europe's trucks for the foreseeable future; and turbocharging is equally applicable to gasoline engines, where it will more than restore any power lost by emission control equipment, while at the same time helping with the emission problem itself.

by I. W. Goodlet  
Holset Engineering Co. Ltd., Huddersfield, England  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n3 p77-87  
Rept. No. 3/74 ; 1974 ; 13p 8refs  
Presented at an Ordinary Meeting of the Automobile Div.,  
London, 10 Jan 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 235

# THE INFLUENCE OF AMBIENT TEMPERATURE AND PRESSURE ON COMPRESSION-IGNITION ENGINE PERFORMANCE

Investigations into the effect of changes in atmospheric pressure and temperature on the performance of a compression-ignition engine without a turbocharger are reviewed. Variations in exhaust smoke and temperature, cylinder peak pressure, coolant-heat flow, engine friction and air flow rate were observed in a Richardo E6 single-cylinder research engine fitted with a Comet Mk V compression-ignition head, an electric swinging field dynamometer, and a mercury in steel thermometer installed 250 millimeters away from the exhaust valve. A method is devised for the prediction of the brake power and fuel consumption of an engine at any pressure and temperature, using information obtained at normal atmospheric conditions only and checked using the results of several investigators. A prediction method for calculating the maximum permissible power output is also suggested in relation to the previously observed rating criteria and the following findings: smoke density increases with fuel/air ratio; exhaust gas temperature increases with inlet temperature and fuel flow rate; peak cylinder pressure is almost proportional to the inlet pressure; and heat flow to the coolant per unit mass of fuel rises at high and low fuel/air ratios.

by P. B. Spence; T. J. Williams  
North East London Polytechnic, Dagenham, Essex, England;  
Univ. of London King's Coll., London, England  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n4 p25-32  
Rept. No. 4/74 ; 1974 ; 10p 13refs  
For presentation at an Ordinary Meeting of the Combustion  
Engines Group, London, 13 Feb 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 236

# TURBOCHARGING THE THREE LITRE V6 FORD ESSEX ENGINE

The reasons leading up to the development of the turbocharged 3 liter V6 Ford Essex engine, the subsequent design considerations, and the findings of an exploratory test program are discussed. Topics evaluated are: the choice of a supercharger; the turbocharger; positioning of the carburetor (upstream or downstream of compressor); obtaining an automotive torque curve (using waste gates, compressor "blow-off" valves, or turbine outlet restrictors); air mass flow requirements; exhaust system considerations; intake system considerations; compression ratio; ignition advance requirements; maximum cylinder pressure; engine performance; engine component design details (piston, cylinder head gasket, exhaust manifold gasket, engine air cleaner, engine breather system, crankshaft torsional vibrations, driveability); computer performance predictions; exhaust emissions; and the future of the turbocharged petrol engine. Power and torque improvements of 30% and 26% respectively have been produced by turbocharging. A compression ratio of 7.6:1 is employed and gasoline of 97 octane number is adequate. It is found that: an acceptable torque curve is obtained by the use of a turbine outlet restrictor, standard intake manifold and standard carburetor (exhaust and intake is also readily controlled); only minor engine component changes are necessary for turbocharging; mechanical reliability presents no problems;

specific fuel consumption is no higher than that of the normally-aspirated version of the engine; and emission of nitrogen oxides is low.

by E. R. R. Fuchs; K. G. Parker; B. T. Pritchard Lovell  
Ford Motor Co., Advanced Engine Design, South Ockenden,  
Essex, England; Garrett Aircsearch, Ltd., Turbocharging Div.,  
Skelmersdale, Lancs., England; Weslake and Co., Ltd., Rye,  
Sussex, England  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n5 p33-47  
Rept. No. 5/74 ; 1974 ; 17p 2refs  
Prepared for presentation at an Ordinary Meeting of the  
Automobile Div., London, 19 Feb 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 237

# FATIGUE AT HIGH TEMPERATURE--PREDICTION AND INTERPRETATION

The significant developments in fatigue over the last 20 years are reviewed as they pertain to the prediction of life in high-temperature service. The Coffin-Manson relationship, the Paris-Anderson fatigue crack propagation law and the advent of closed-loop testing techniques in the laboratory are discussed. Particular attention is given to the interpretation of fatigue test results for both low and high cycle fatigue at room and elevated temperatures. Emphasis is given to such effects as environment, frequency and strain rate, metallurgical factors, wave shape and thermal cycling, and an attempt is made to determine their relative importance. It was found that: fatigue failure in the low cycle regime is best described by the Coffin-Manson relationship and most of the lifetime is consumed in crack growth; in the high cycle regime nucleation takes up most of the life while growth can be represented by fracture mechanics concepts; at elevated temperatures environment is the principal cause of degradation in fatigue resistance for both low and high cycle fatigue; and the effects of temperature and frequency are often negligible when tests are conducted in high vacuums. Frequency effects are discussed in terms of microstructural strain localization and a model is presented to illustrate the frequency regimes. Through the concept of smooth specimen simulation, an example is given of how laboratory test data can be applied to the prediction of notch fatigue behavior at high temperature with low frequencies or with hold times. Closed-loop testing methods permit a wide variety of wave shapes. It is suggested that certain regimes exist where such unbalanced loops of creep deformation in one direction and rapid reverse deformation can cause microstructural ratcheting failure and lead to greater degradation than in fatigue failure under balanced loops. Thermol cycling and in-phase balanced mechanical strain cycling can produce similar effects. These deformation processes are accompanied by strong environmental interactions. The significance of these factors to the current state of life prediction and to future directions for development is considered.

by L. F. Coffin, Jr.  
General Electric Co., Corporate Res. and Devel., Schenectady,  
N.Y.  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n9 p109-27  
Rept. No. 9/74 ; 1974 ; 21p 80refs  
Presented at an Ordinary Meeting of the Inst. for Mechanical  
Engineering, Univ. of Sheffield, 1 Apr 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 238

# **THE TRAINING NEEDS OF THE PROFESSION FOR THE NEXT DECADE**

The training of professional engineers is discussed from primary to university education. A proposal is made for a system of mentor and tutorial guidance extending from the sixth form to management. At each stage of development (sixth form pupil with engineering intentions, the interview at end of school, the industrial student, the undergraduate, the graduate engineer, the professional engineer, and the manager) the responsibilities of the various participants are outlined, and proposals are made for training and educational programs. Management development is covered in detail. The training of management is outlined in terms of the following necessary skills: planning, ability to motivate, problem solving, organizing, controlling, and leading. The special character and value of the design engineer is also considered.

by F. Shaw

Rover British Leyland U.K. Ltd., Transmissions, Solihull, England

Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n10 p141-51

Rept. No. 10/74 : 1974 : 13p 93refs

Prepared for presentation at an Ordinary Meeting of the Automobile Div., London, 9 Apr 1974.

Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 239

# **A NEW CONCEPT OF TRUCK TRANSMISSION DESIGN**

The existing principles used in the design of synchronized mechanical transmissions are reassessed from the point of view of synchronizer duty. A new transmission concept is reported. Known as the "M" series, its advantages are: saving of weight; faster synchronization, making for greater road safety; less space; lower manufacturing costs; synchronization for larger transmissions; greater isolation of "gear jump-out" influences; use of up-to-date bearing techniques; and maximum use of common tooling. A four-speed, constant-mesh transmission; a five-speed synchromesh transmission; some failures in man-drive gears and synchronizers; and the new M series are illustrated. A theoretical study is presented comparing the expected performances of the M series with that of a conventional five-speed synchronized transmission under identical conditions. Performance factors compared are: synchronizer performance; speed of components at maximum speed in gears; heat ratings; speed of component parts; loads, deflections and bearings; and joint-face problems. In addition, the following items are discussed: the planning of a transmission design family (with illustrations of a five-speed and a six-speed M series transmission); gear selection mechanism (with illustration); and heavy-duty transmissions (with illustrations of a typical Dana-Spicer, multi-speed, constant-mesh, twin-coun-

tershaft, split-torque transmission; and of M series, six and 11-speed, heavy-duty, dual-path, synchronized transmissions).

by W. M. M. Morrison

Turner Mfg. Co., Ltd., Wolverhampton, Staffs., England

Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n12 p169-87

Rept. No. 12/74; 1974 : 21p 5refs

For presentation at an Ordinary Meeting of the Automobile Div., London, 14 May 1974.

Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 240

# **ACHIEVING QUALITY AND RELIABILITY**

Nine conferences on quality and reliability organized by the Institution of Mechanical Engineers during the last decade are summarized. The variation of first, operating, maintenance, and revenue loss costs with reliability is illustrated. Optimum design is identified with minimum total life cost, which is closely related to reliability. From an examination of reliability theory, it is determined that reliability depends crucially on safety margin and loading roughness. Even though safety margin is a design feature resulting from strength reduction through increased use of lighter materials, both factors can be operator controlled. The matching of design to the requirements of the user in the intended environment is considered most important. The inattention to details and the needless complexity of some designs are factors that need improvement. It is shown that design for prescribed levels of reliability presents formidable difficulties. The design process is discussed, taking the above and maintenance constraints into account. Design, development and re-design are stressed as the keys to quality and reliability. The need for good management to ensure optimum quality and reliability is discussed in terms of management's function in design, educational and training requirements, and management action.

by A. D. S. Carter

Royal Military Coll. of Science, Dept. of Mechanical Engineering, Shrivenham, Oxon., England

Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n13 p201-13

Rept. No. 13/74 : 1974 : 15p 60refs

For presentation at an Ordinary Meeting of the Inst. of Mechanical Engineers, London, 15 May 1974.

Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 241

# **SOME ASPECTS OF THE LUBRICATION OF WANKEL-TYPE ROTARY ENGINES.**

The following aspects of the lubrication of Wankel-type rotary engines are considered: the operation, pre-ignition, and wear of rotary engines; studies on rotary engine lubrication; and lubricant development. Oil's antiwear properties in a rotary engine were tested in a low-speed cyclic test, and a non-stop test. It is shown that the choice of base stock reduces apex-seal wear. The influence of volatility, and of the quantity and viscosity of the oil residue after heating are emphasized. Cyclic tests for pre-ignition found a connection between the ash content of the oil and the severity of pre-ignition. Testing of anti-wear formulations for pre-ignition (not yet conclusive) was found to be necessary. Engine operation and smoothness



are discussed in terms of the spark plugs, the fuel-air mixture strength, and the fuel composition. Spark plugs and mixture strengths were found to be the most important factors, fuel having only a secondary effect. Lubrication studies were conducted on four rotary engines using metallic or carbon-metallic apex seals. Thirteen different oil formulations, including passenger-car-engine oils corresponding to American Petroleum Institute (API) SC, SD, or SE categories, automatic transmission fluids of the Dexron II type, and oils for two stroke engines were tested. Both engine bench test stands and vehicles on chassis dynamometers were used. Satisfactory engine performance was obtained with oils containing from 0 to 1.2% by weight of sulfated ash. The ability of the base stock to provide good oil film thickness was also found of benefit in reducing engine wear. Passenger-car-engine oils can be excellent rotary-engine lubricants and those oils corresponding to the latest API SE classification fluids also gave promising results. Aspects of the lubricant development work which has been done for the European Wankel engine are described. The lubricant requirements of the Audi-NSU Ro80 engine are discussed in comparison with the performance level of lubricants currently in use with conventional reciprocating piston engines. Cold-wear tests, pre-ignition tests, endurance and cleanliness tests, 100 hour endurance tests, and exhaust emissions considerations are described. High-speed pre-ignition has been one of the main causes for concern in Europe, however, cold wear of cast-iron apex seals under "stop and go" driving conditions, created conflicting performance requirements for the lubricant under development. Compromise lubricant formulations were developed giving freedom from pre-ignition, and a marked decrease in cold wear rates, and maintaining the other desirable properties necessary for satisfactory Wankel-engine performance.

by B. Brandone; Jh. du Jeu; J. Y. Breau; B. J. Miller; P. Moller; T. W. Rogers; D. A. Beavis; A. Towle  
TOTAL Centre de Recherches, Harfleur, France; Mobile Res. and Technical Service Lab., Stanford-le-Hope, Essex, England; Mobile Oil AG, Tinsdaler Weg, West Germany; Mobil Res. and Devel. Corp., Paulsboro, N.J.; Lubrizol International Labs., Duffield, Derby, England; Lubrizol Ltd., London, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n14 p289-308  
Rept. No. 14/74 ; 1974 ; 22p 15refs  
Presented at a Joint Meeting of the Automobile Div. and the Tribology Group, London, 6 Mar 1974. Includes three papers: "Rotary engines: Operation, Pre-ignition and Wear"; "Recent Studies on Rotary-engine Lubrication"; and "Lubricant Development for the Wankel-type Rotary Engine."  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 242

### ELASTOHYDRODYNAMIC LUBRICATION OF A LINE CONTACT

Optical interferometry is used to study an elastohydrodynamically (oil) lubricated line contact between a taper roller and glass plate under pure rolling conditions. The rolling element (a thrust bearing assembly) and the loading system (a hydrostatic bearing loading the plate against the roller) are diagrammed. The end blending of rollers is investigated with calibrations of load, phase change, refractive index, and roller end profile under static and dynamic conditions. Film profiles are plotted out at various speeds and loads. The effect on the film of lubricant starvation and a deep scratch are also studied; and the ability to form static oil entrapments is demonstrated. Star-

vation is shown to be far more prevalent than usually assumed. Once the extent of starvation is known, its effect on film thickness can be determined. The effect of deep scratches is dramatic though not unexpected and entrapments are seen to form as easily, on suddenly stopping, with line contacts as they are with point contacts. Using the line contact apparatus, a set of oil film thickness measurements is presented covering a range of loads, speeds and lubricants. Two empirical film thickness formulas are derived. Optical measurements of starvation, heating, variation of film thickness, and minimum thickness at roller exit are made. In addition, electrical measurements of the connections, resistance, and capacitance were made. Comparison of theoretical and experimental film thickness shows a difference of 15% between theory and experiment in the values for minimum film thickness. Comparison between optical and capacitance measurements of film thickness shows that: resistance can give a good measure of the film thickness as a ratio of the roughness; and the capacitance method agrees well with the optical value for the mid-point film thickness. The silica layer technique of capacitance measurement is found to be a valuable advance allowing higher voltages, higher frequencies, and higher roughness.

by D. G. Wymer; A. Cameron  
Imperial Coll., Lubrication Lab., London, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n19 p221-38  
Rept. No. 19/74 ; 1974 ; 20p 21refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 243

### THE LUBRICATION OF PISTON RINGS

A capacity gauge, designed for operating within a working engine, and its use and installation are discussed. The method of using it for determining the oil-film thickness and piston-ring profile is described. Measurements were carried out on a single-cylinder, four-stroke, diesel engine operated in a closed cell. A standard piston was used fitted with a set of five cast-iron rings already broken in. An SAE 30 heavy-duty engine oil formulated from mineral oil and conventional detergent additives with a viscosity index of 96 was used. The output from the individual gauges was fed into a capacity bridge and the bridge output was fed into an oscilloscope and synchronized with the piston position in the engine. Synchronization was effected by means of a magnetic pick-up driven through a two-to-one reduction gear by the main shaft, which made it possible to distinguish the induction and compression strokes from the firing and exhaust strokes. Graphs are presented of oil-film thickness in micrometers at 11 positions across each piston ring. The oil-film thickness between the piston ring and cylinder liner was found to be in the range of 0.4 to 2.5 micrometers and appeared to be hydrodynamic in character, the thickness increasing with increasing speed and viscosity, and decreasing with load. An alternative method of solving the hydrodynamic equations of lubrication of a piston ring is described. Some results of the calculations are compared with the measured values of oil-film thickness in an actual engine. It is shown that there are disagreements from a factor of 2 to a factor of 8 between the theoretical and measured values. This is explained by the complicated nature of the ring pack. Further experiments were carried out on a single ring in a motored rig with the same measuring system as the engine used above. It was shown that although the film thickness is con-

siderably greater, it is still not in complete agreement with the theory.

by G. M. Hamilton; S. L. Moore  
The Univ., Tribology Unit, Whiteknights, Reading, England  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n20 p253-68  
Rept. No. 20/74 ; 1974 ; 18p 10refs  
Includes two papers: "Measurement of the Oil-film Thickness between the Piston Rings and Liner of a small Diesel Engine"; and "Comparison between Measured and Calculated Thicknesses of the Oil-film Lubricating Piston Rings."  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 244

# AIR MOTION IN A FOUR-STROKE DIRECT INJECTION DIESEL ENGINE

The results of a study of the air motion in a motored four-stroke direct injection diesel engine using hot-wire anemometry are presented. Factors which influence and produce air motion in high-speed diesel engines (introduction swirl, and compression swirl), the advantages and disadvantages of the techniques used, and results obtained in the past are discussed. An air-cooled direct injection diesel engine motored through a belt system with a direct current motor was used in the study. A three-wire anemometer probe to measure velocity and direction of the air flow, and a two-wire probe to study the effects of mean swirl and squish motion in the bump clearance were used. The gas velocity was computed from the hot wire anemometer output voltage in a variable density flow, by measuring the gas temperature with one of the wires of the three-wire probe used as a resistance thermometer and by measuring the gas pressure with a pressure transducer. The experiments covered an engine speed range of 500-1500 rpm and determined the effects of valve masking and supercharging on mean air swirl. Cylinder air motion is also modelled theoretically. The following air flow factors are considered: induction swirl period; compression swirl period; and squish motion. The model is found to be in acceptable agreement with the experimental results. It is shown that a forced vortex solid body movement occurs in the direct injection diesel engine over a large part of the induction and the whole of the compression period. The model shows that what was previously considered a squish movement of the air during the last stages of the compression process is, in fact, the inward radial flow component spiralling in towards the combustion bowl.

by J. C. Dent; J. A. Derham  
University of Technology, Dept. of Mechanical Engineering, Loughborough, Leics., England; Unilever Res. Lab., Bedford, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n21 p269-80  
Rept. No. 21/74 ; 1974 ; 14p 19refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 245

# NEW FAMILY OF HIGH-RATIO REDUCTION GEARS WITH MULTIPLE DRIVE PATHS

A new family of high-efficiency, high-ratio reduction gears is described in which a counter-rotating epicyclic gear distributes power equally between two, three, and four parallel drive

paths. The mechanisms employ zero stiffness torque-balancing within and external to the epicyclic unit and work within a spectrum of operation bounded by designs having a fixed annulus or a fixed planet carrier. A theory is developed to investigate the principal design problems associated with reduction ratios, bearing speed, centrifugal loading, bearing life and epicyclic efficiency. A primary application is to high-output torque transmission systems such as those used in helicopters. It is found that: high efficiency results from using a minimum number of geared stages while avoiding recirculation of power through any gear mesh; large reduction ratios can be generated by a counter-rotating epicyclic unit used in conjunction with small diameter gear pinions, carrying part input power, at the final reduction stage; increased reduction ratios obtained with typical power split ratios result in lowered centrifugal loads on the planet pinion bearings permitting planetary units of simple construction to be used, even with ultra-high input speeds, while retaining the advantage of rolling-contact bearings in the planet pinions; and the developed theory confirms that the drive paths do constitute a mechanism family.

by G. White  
University of Technology, Dept. of Mechanical Engineering, Loughborough, Leics., England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n23 p281-8  
Rept. No. 23/74 ; 1974 ; 10p 3refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 246

# COMMERCIAL-VEHICLE CABS: DESIGN FOR PACKAGING, ACCESS AND VISIBILITY

Particular aspects of commercial-vehicle cab design are reviewed, important influences are stressed and design solutions are discussed to provide guidance in the derivation of cab design with special reference to packaging, accessibility, and visibility. Certain conflicting requirements, design problems and solutions are discussed and observations on the possible future trends in cab design are included. Main chassis factors influencing the packaging of the front end of the commercial vehicle are discussed: power units, the wheel arches, and the impact requirements. Body-system constraints are considered and vehicle access for cabs of light commercial vehicles, medium cabs, and high cabs, and for service work is discussed. A typical form and visibility study for a high cab, a typical field-of-vision plot for a heavy commercial vehicle, and a post obscuration study are diagrammed and the cost benefits of cab design are considered.

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Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n24 p345-56  
Rept. No. 24/74 ; 1974 ; 14p 11refs  
Prepared for presentation at an Ordinary Meeting of the Automobile Div., Leyland, England, 8 Oct 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 247

HS-017 247

# **LOW-CYCLE FATIGUE BEHAVIOUR [BEHAVIOR] OF GAS TURBINE ALLOYS**

Low-cycle fatigue characteristics of an 11% chromium steel, two nickel alloys and two titanium alloys were studied in the range of 20° to 500°C. Cylindrical test pieces were tested between fixed load limits and tensile strain limits with a lever-type machine at a frequency of 3 cycles per minute and in a closed loop servo-hydraulic fatigue machine at higher frequencies. Repeated-tension stress for rupture behavior, fractography, the influence of temperature, and the effect of frequency are discussed. A sharp break in the stress-endurance curve was found between 1,000 and 10,000 cycles per minute. The following tests involving compressive minimum loads either through load or strain cycling (push-pull cycles) were conducted on the steel and one of the titanium alloys: variable minimum compressive load tests; fully reversed load cycling tests; and tensile strain cycling tests. The effect of stress concentrations on repeated-tension fatigue for conventionally-machined notches, extensometer ridges, and sharply-slit notches is discussed. The high stress failures were attributed to cyclic creep contributing to the development of internal cavities. At lower stresses, failures occurred through the growth of fatigue cracks initiated at the material surface. It was found that the whole fatigue curve could be represented by an expression developed from linear damage assumptions. Data for the different temperatures of types of stress concentration were correlated by expressing stress as a fraction of the static strength. Repeated-tensile strain cycling data were represented on a stress-endurance diagram and it was shown that they correlated with push-pull stress cycles at high stresses and repeated-tension cycles at low stresses. The compressive phase tended to accentuate cyclic creep so that ductile failures occurred at proportionally lower stresses. Changes in frequency from 1 to 100 cycles per minute were shown to have no significant effect on low-cycle fatigue behavior.

by W. J. Evans; G. P. Tilly  
National Gas Turbine Establishment, Pyestock, Hants., England; Transport and Road Res. Lab., Crowthorne, Berks., England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n27 p321-28  
Rept. No. 27/74 ; 1974 ; 10p 14refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 248

# **HYDROGEN AS A FUEL FOR VEHICLE PROPULSION**

The feasibility of hydrogen as a fuel for future vehicle propulsion is considered in terms of fuel availability, economics, and storage. The price of hydrogen, when produced in bulk, is shown to be very close to the present price of gasoline. Hydrogen requires a larger storage volume than gasoline to provide an equivalent energy content. The use of metal hydrides for hydrogen storage is discussed. The compatibility of a hydrogen air engine with possible future requirements is assessed. The rate formation of nitric oxide, based on the rate kinetics in a hydrogen-air mixture, indicates a higher nitric oxide concentration in the exhaust gas of a hydrogen engine than in the exhaust gas of an equivalent gasoline engine. Engine design and operation are considered. Methods of charging the engine (injection, hydrogen induction, hydrides) are men-

tioned. Hydrogen fuel has demonstrated either good thermal efficiency at low power output (when the hydrogen-air mixture was lean) or a power output equivalent to a gasoline engine at the cost of high fuel consumption. Certain engine design parameters (size, cooling system, piston rings, fuel injection) which may have to be changed to achieve desired performance are considered. Methods of reducing nitric oxide emissions are discussed. It is concluded that hydrogen can be used for vehicular propulsion without much change in performance or cost of operation.

by K. S. Varde; G. G. Lucas  
Loughborough Univ. of Technology, Dept. of Transport Technology, Loughborough, Leics., England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n26 p365-72  
Rept. No. 26/74 ; 1974 ; 10p 25refs  
For presentation at an Ordinary Meeting of the Automobile Div., Luton, England, 19 Nov 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 249

# **FLUID-ACTUATED TEMPERATURE SENSOR**

A new design of fluid-actuated temperature sensor called the thermopad is described. It may be constructed to give either a positive or negative change of resistance for an increase of temperature and may be capable of fluid shut-off. The operating characteristics are given for three different configurations operating with air (thermopad of positive resistance gradient, thermopad of negative resistance gradient, adjustable thermopad) illustrating the high-pressure gain possible with this type of temperature sensor. A theoretical analysis of the thermopad is provided. The three thermopads were tested using different circuits. A thermopad and thermocouple attached to a thermopad were dropped in boiling water and removed to cool down in the atmosphere so that change in output pressure with temperature change might be determined. It is concluded that: the design of the thermopad is simple and it can be easily manufactured; the thermopad can be designed to give either an increase or decrease in the output pressure with an increase in temperature; the sensitivity of the thermopad depends on its parameters and the supply pressure (high sensitivity can be obtained without external amplifications); and the response of the thermopad is faster to changes in temperature than similar temperature sensors, such as the bi-metal strip, thermostat or capillary restrictor, due to the absence of moving parts.

by S. A. Morsi  
University of Surrey, Dept. of Mechanical Engineering, Guildford, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n36 p381-7  
Rept. No. 36/74 ; 1974 ; 9p 7refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 250

# **THE ROLLS-ROYCE RB 211 TURBOFAN ENGINE**

A technical account is given of the Rolls-Royce RB 211 42,000 pound thrust turbofan engine now powering the Lockheed Tri Star passenger transport. The development of the engine from preliminary design studies to use with a number of American airlines is described. Low fuel consumption, low noise, and



low maintenance costs were the principal objectives. An idea of the large scale of the RB 211 project is given. The design objectives of the engine are given and the engine and the power plant (acoustic linings, thrust reverser, engine/power-plant modular assemblies, routine servicing, condition monitoring, and transport) are briefly described. Some of the development problems and the rig testing, engine bench testing and large-scale testing of the engine and power plant are discussed. The principal service problems (fan disc, short life of the turbine blades, combustion chamber, malfunctioning of hot-stream thrust spoiler, compressor surge, cracking of intermediate compressor casing, and removal rate in service) and their remedies are described. The design of the engine to certain noise control targets is discussed. A special research engine, the high temperature demonstrator unit, built to bridge the gap between previous research and full-scale engine conditions is described. Also discussed are: the engine performance, present and future (thrust, specific fuel consumption, and noise now equal or better the design targets); a developed version of the RB 211, now being tested at over 50,000 pounds thrust; and potential for further developments in fuel consumption and for expected additional aircraft and industrial applications.

by E. M. Eltis; G. L. Wilde  
Rolls-Royce Ltd., Derby, England  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n37 p549-75  
Rept. No. 37/74 ; 1974 ; 29p 11refs  
Prepared for presentation at Ordinary Meetings of the  
Institution held at the following: Bristol Univ., 10 Dec 1974;  
Leicester Polytechnic, 24 Jan 1974; and Univ. of Leeds, 18  
Feb 1974  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 251

#### FOUR-CYLINDER, FOUR-CYCLE ENGINE WITH TWO RECIPROCATING COMPONENTS

The design and construction are described of a prototype four-cylinder 1600 cubic centimeter gasoline engine, containing Cross rotary valves and a new crank mechanism allowing two reciprocating components. Discussed are: the advantages of the Cross rotary valve; Cross valve sealing; Cross valve lubrication; application of the Cross rotary valve; and an eccentric-crank mechanism. Detailed construction of the engine is described in terms of the following: the crankshaft; the eccentric cluster; yoke-piston assemblies; valve construction; and cylinders and valve caps. Illustrations are provided. Computer printouts are provided showing the influence of crankshaft velocity, gas pressure, crankshaft angles, and reciprocating weight upon the forces generated within the engine. The yoke-piston structure was looked at against the pattern of calculated forces and designed so as to produce relatively small deflections and stress levels in the eccentric strap. Mathematical analysis of statics within the eccentric-crank mechanism and of the dynamic balance of the eccentric crank mechanism are provided. It is concluded that in the present fuel shortage, the low fuel consumption and octane requirements of the Cross combustion chamber will be important, while the compactness

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by R. V. Jones  
Aberdeen Univ., Dept. of Natural Philosoc  
Scotland  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n39 p585-96  
Rept. No. 39/74 ; 1974 ; 14p 68refs  
Prepared for presentation at an Ordinary Meeting of the  
Institution, London, 11 Dec 1974.  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 253

#### CUMULATIVE DAMAGE IN FATIGUE UNDER MULTIAXIAL STRESS CONDITIONS

Previous investigations into cumulative damage fatigue under uniaxial stress are discussed. The results of two-level block program tests on 2L65 aluminum alloy at four values of constant principal stress ratio and at several combinations of two different principal stress ratios are presented and discussed with reference to cumulative damage criteria developed for the case of uniaxial fatigue stress (the Miner rule, stress dependence and interaction, stress-dependent criterion and interaction criterion). A biaxial fatigue test machine, capable of subjecting thin-walled tubes to the combined effects of pulsating internal pressure and either pulsating tension or compression end load, and an eight-stage block programmer operating by changing the input resistors to an operational amplifier were combined for conducting the fatigue tests. No significant effect on the principal stress ratio was shown, whether the maximum shear stress amplitude occurs on the isotropic or anisotropic shear stress planes. Values of cycle ratio sums were found between 0.13 and 1.82 with an overall mean of

0.77. A uniaxial stress-dependent criterion was found to have possible application to these results whereas no correlation could be found with present uniaxial interaction criteria. Also, strong interaction effects between the two principal stress ratios were found and stress levels greater than 70% of the fatigue strength at one million cycles had to be taken into account.

by D. L. McDiarmid  
City Univ., Dept. of Mechanical Engineering, London, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n40 p423-30  
Rept. No. 40/74 ; 1974 ; 10p 20refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 254

#### **CALCULATION OF NITRIC OXIDE AND CARBON MONOXIDE CONCENTRATIONS IN SPARK-IGNITION ENGINES**

The effects of simplifying kinetic assumptions in calculating nitric oxide (NO) formation in spark-ignition engines are discussed, and kinetic models are used to predict NO and carbon monoxide (CO) concentrations. The amount of NO developed in a spark-ignition engine was calculated for a range of fuel-air ratios at each of two compression ratios. A set of 16 reactions, chosen as the most important in controlling the variation of composition of exhaust, is given. Three programs were developed with the same basic framework, but with different degrees of kinetic complexity: by which equations of all 16 reactions were embodied in differential equations; only reactions involving nitrogen (N) and oxygen (O) were represented by rate equations; and, finally, all differential equations for species concentration except the one for NO were eliminated. All calculations were carried out on a naturally-aspirated engine at full throttle and a single engine speed. It is concluded that: it is not necessary to consider a departure of CO from equilibrium in calculating NO formation; nitrous oxide (N<sub>2</sub>O) reactions may be disregarded at the cost of a small underestimation of NO; the reaction of N and hydroxide (OH) giving NO and hydrogen (H) cannot be disregarded without appreciable error, especially at rich fuel-air ratios; the quasi-steady approximation for N and N<sub>2</sub>O concentrations proposed by Lavore is completely satisfactory at engine conditions. The kinetic equations of elementary chemical reactions during the expansion process of the engine are incorporated in a cycle synthesis computer program, which can be used to calculate the thermodynamic state and the concentration of a number of compounds in the exhaust. The stability and accuracy of the program are discussed and the validity of the results is confirmed by comparing the theoretical predictions with experimental results. It is concluded that: it is very important to have equilibrium-balanced forward and reverse rate coefficients and equilibrium compatible initial values of concentrations of compounds and elements; the final results and computation time are affected by these factors, especially at stoichiometry; the early departure of CO concentrations from the equilibrium value may suggest that the assumption of equilibrium concentrations at the peak temperature will introduce some errors; the concentration of some compounds may overshoot the initial equilibrium values at the peak temperature, and the predicted variation of CO across the burnt

charge calculated from an unmixed model shows very little variation in mean value (in most cases it can be ignored).

by H. Daneshyar; M. Watfa; W. J. D. Annand  
Cambridge Univ., Dept. of Engineering, Cambridge, England; Univ. of Manchester, Pollution Res. Unit, Manchester, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n41 p431-45  
Rept. No. 41/74 ; 1974 ; 17p 25refs  
Includes two papers: "Effects of Simplifying Kinetic Assumptions in Calculating Nitric Oxide Formation in Spark-ignition Engines"; and "Predicting Nitric Oxide and Carbon Monoxide Concentrations in Spark-ignition engines."  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 255

#### **INCIPIENT LIFT-OFF IN PRELOADED PLANE EXTERNALLY-PRESSURIZED COMPLIANT SURFACE BEARINGS**

The coupled elasticity and hydrodynamic equations are solved for a plane externally-pressurized bearing consisting of an elastic layer bonded to a rigid substrate. Solutions for bearing load support, flow and minimum lubricant film thickness are presented for a wide range of bearing geometries and for both compressible and incompressible lubricants. For preloaded bearings (bearings with interference fits such that the compliant surface is initially indented by the mating surface) a criterion for incipient lift-off is postulated and formulas for calculating the lift-off pressure are derived. Theoretical findings are supported by existing experimental data. Lift-off pressure is found to be such that if applied uniformly over the compliant surface, the deflection produced at the exit edge will equal the preload indentation.

by P. K. Gupta  
Mechanical Technology, Inc., Latham, N.Y.  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n42 p447-55  
Rept. No. 42/74 ; 1974 ; 11p 9refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 256

#### **SURFACE ROUGHNESS OF GRAPHITE AND ITS EFFECT ON FRICTION FACTOR**

Tests were conducted to determine the friction factor and surface finish measurements of eight graphite tubes machined to give a range of surface finishes from smooth to the maximum roughness likely to occur in a reactor. Machined graphite cannot generally be regarded as a hydraulically-smooth surface under gas-cooled reactor conditions. Correlations are given which allow estimation of the friction factor from graphite surface finish measurements. The results are compared with those obtained by Nikuradse in his sand-grain roughness tests. Except at low values of effective roughness height, agreement is good, enabling the heat transfer similarity law of Dittus and

Sabersky to be used to predict any change in heat transfer performance due to surface roughness.

by C. Warburton  
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Berkeley, Glos., England  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n43 p457-60  
Rept. No. 43/74 ; 1974 ; 6p 7refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 257

#### MIXED LUBRICATION AND SURFACE TOPOGRAPHY OF ROLLING CONTACTS

Measurements of friction torque in a tapered roller bearing are made over a range of axial loads at low rotational speeds. Two tapered roller bearings arranged back-to-back were driven at their inner races or cones and the torque reaction at the floating outer races, or cups, were measured by means of a torque arm. Under the given conditions, considerable metallic contact between surface asperities occurs. Experimental and theoretical values of no-contact time are compared. The usually adopted ratio of calculated film thickness to gross surface root mean square value is shown to be a less meaningful measure of the quality of lubrication than one based on the rms after filtering out contributions due to asperities of wavelength greater than twice the Hertzian width. An analysis of the statistical properties of worn and unworn surfaces is made. Digital filtering of the power spectrum reveals differences that are not apparent in the unfiltered data. Asperities of long and very short wavelengths, compared with the Hertzian width, are shown to be little affected during running-in while those of intermediate size are removed.

by R. H. Leaver; R. S. Sayles; T. R. Thomas  
Teesside Polytechnic, Dept. of Mechanical Engineering,  
Middlesbrough, England  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n44 p461-69  
Rept. No. 44/74 ; 1974 ; 11p 20refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 258

#### NITRIC OXIDE FORMATION IN DIESEL ENGINES

A combustion model is presented to account for the nitric oxide (NO) formation in diesel engines at all operating conditions. The rate constants used for the reactions (leading to the formation and decomposition of NO in compression-ignition engines) are taken from shock-tube studies of the kinetics of NO at high temperatures. An attempt is made to introduce the concept of variable air-fuel ratio estimated to exist during diesel combustion. A spark-ignited diesel hybrid engine, and an International Harvester single-cylinder test engine were used to determine the actual NO emissions under variable operating conditions (of speed, load, injection advance, and exhaust gas dilution). Computations performed for 25 different engine operating conditions resulted in NO concentrations that compared well with the emissions measured in the experimental set-up. It is suggested that the model be tried on open-chamber and other types of engines operating more truly on

the diesel cycle. The reduction of NO emissions will be the object of further investigation.

by H. Cakir  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n46 p477-83  
Rept. No. 46/74 ; 1974 ; 9p 12refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 259

#### EFFECT OF THREE WAY CONVERSION CATALYST OPERATION ON THE CHEMICAL STATE OF AUTOMOTIVE SULFUR EMISSIONS

The effect of the three way conversion (TWC) catalyst operation which uses essentially stoichiometric air-fuel (A/F) ratios with a catalyst capable of simultaneous conversion of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO) is discussed as a method of sulfate emissions control. The possibility of forming hydrogen sulfide (H<sub>2</sub>S) from sulfur dioxide (SO<sub>2</sub>) by the use of catalytic purifiers without secondary air pumps or by the use of TWC catalysts is examined. The thermodynamics of sulfate formation in automotive exhaust is examined and discussed theoretically. Experiments were conducted on a laboratory bench reactor (with an aged TWC and an oxidation catalyst at A/F ratios near stoichiometric), an engine dynamometer (with an aged TWC catalyst), and three vehicles (1975 Volvo 242, Ford Torino, and Chevrolet Chevelle with aged TWC catalysts) to determine the oxidation and reduction effect on SO<sub>2</sub> under those conditions. It was found that: sulfate emissions (conversion of SO<sub>2</sub> to sulfur trioxide) are strongly dependent on free oxygen concentration; sulfate emissions from vehicles equipped with TWC catalysts and oxygen sensor control are near zero; the TWC catalyst system is durable and meets 1975-76 California Interim Standards; sulfate emissions from vehicles equipped with aged oxidation catalysts operated without an air pump are very low and meet the 1975-76 California Interim Standards; and the possible occurrence of H<sub>2</sub>S formation because of operation or transient excursions into the reducing region is small.

by J. G. Cohn; W. A. Mannion; C. E. Thompson; J. G. Hansel  
Engelhard Minerals and Chemicals Corp., Engelhard Industries  
Div., Menlo Park, N.J. 08817  
Rept. No. SAE-750096 ; 1975 ; 13p 18refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 260

#### APPLICATION OF A PHOTOGRAPHIC METHOD TO DETERMINE THE VISIBILITY OF A COWHIDE [AUTOMOBILE HEADLAMPS]

Questions on the visibility and detection of a Shorthorn-Hereford steerhide under photopic and mesopic conditions are presented. Photographs of the hide, representing what the human observer sees under varied conditions are presented, in order to give a qualitative and quantitative description of the phenomenon. A combination of photographic filters (K2 and X1) used on a wide band film indicates a decrease in reflectance of 18% when red sensitivity is partially lost while viewing a red cowhide in the laboratory under low levels of illumination corresponding to the ones arising from low beam



headlights. A theoretical calculation reveals that, for a source of color temperature of 3000 degrees K, the decrease in reflectance corresponding to a total loss of red sensitivity is about 40%. Comparison between the two approaches indicates that the photographic method yields the correct order of magnitude for the effect. Moreover, it gives a very good visual description of the phenomena associated with a partial loss of red sensitivity, as in the case when the human observer's spectral response function is in the mesopic range. Photopic values were used for the hide's reflectance.

by A. A. Ayad  
National Res. Council Canada, National Aeronautical  
Establishment, Ottawa, Canada  
Rept. No. LTR-ST.767 ; 1975 ; 21p 8refs  
Availability: Corporate author

HS-017 261

### CASE STUDIES CONSIDERED AS RETROACTIVE EXPERIMENTS

A methodology for combining automobile crash investigation case studies into an overall statistical analysis is presented. The method considers each case study as an experiment identified by a set of independent variables. For each experiment a dependent variable (such as occupant injury) is measured. Analysis of the relationship between the independent variables and the dependent variable can then be performed. Two basic data sets from the Collision Performance and Injury Report (CPIR) file (2705 occupant injuries in Washtenaw County, Michigan during 1970-1972, and all occupant injuries in the file from crashes during 1969-1972) are used in a multiple regression analysis fitting an injury prediction model. An analysis of the effect of restraint systems on accident injury level is presented, considering all occupants and considering persons in the front seat only. It is concluded that: occupants who were not wearing any restraint device were involved in crashes which had a slightly higher expected severity; and seat belts and upper torso restraints each contribute an increment of occupant injury severity reduction, even after the differences in crash severity have been controlled. An important application of this overall approach involves the use of an injury prediction model to compute an expected injury conditional on crash severity. The expected injury is subtracted from the observed to yield an injury statistic which is corrected for differences in crash severity. This corrected injury can then be used to compare, for example, the effectiveness of various vehicle components with respect to injury severity reduction.

by William L. Carlson; Richard J. Kaplan  
Publ: Accident Analysis and Prevention v7 n2 p73-80 (Jun 1975)  
1975 ; 4refs  
Supported by the National Hwy. Traffic Safety Administration.  
Availability: See publication

HS-017 262

### THE EFFECT ON CASUALTIES OF A COMPULSORY SEAT BELT WEARING LAW IN SOUTH AUSTRALIA.

A compulsory seat belt wearing law in South Australia was preceded by a rise in the belt wearing rate and accompanied

by a further substantial rise. Casualty rates per 1000 involved vehicles, reported on a property-damage criterion, showed lower rates for 1967 and later models, which had belts compulsorily fitted, both before and after the wearing law. A before and after comparison showed reductions in the serious grades of casualties and an increase in the least serious. There was a differential effect on casualty reduction in 1967 and later models, which accounted entirely for the 7.5% overall reduction in the fatality rate. These comparisons are substantially free of effects due to concurrent changes in exposure to risk of accident and the observed reductions can be attributed to the belt wearing law.

by J. D. Crinion; L. A. Foldvary; J. C. Lane  
Publ: Accident Analysis and Prevention v7 n2 p81-9 (Jun 1975)  
1975 ; 9refs  
Availability: See publication

HS-017 263

### INFLUENCING FACTORS FOR RAILROAD-HIGHWAY GRADE CROSSING ACCIDENTS IN FLORIDA

Multiple regression was used to investigate the influence of physical factors on accident rates at 1,140 rail-highway grade crossings in Florida. Selection of the final model involved examination of residuals, transformation of variables, dummy variables and interaction terms. Variables in the final model were functions of average daily traffic, type of crossing protection, maximum train speed, trains per day, crossing speed limit, and number of lanes of traffic. Transformations were made to return estimates to the original scale of the data. Suggestions made for improving the model and the data included: investigation of the data coding process for small samples; studying accident reports for crossings at which the observed number of accidents greatly exceeded the predicted number; and the compilation of profiles for drivers involved in accidents.

by G. van Belle; D. Meeter; W. Farr  
Publ: Accident Analysis and Prevention v7 n2 p103-12 (Jun 1975)  
1975 ; 4refs  
Availability: See publication

HS-017 264

### COMBATting ROAD ACCIDENTS: INTERNATIONAL CO-OPERATION IN ROAD TRAFFIC SAFETY RESEARCH

Recognizing the importance of statistical methods in road accident analysis, the Road Research Program of the Organization for Economic Co-operation and Development (O.E.C.D.) attempted to evaluate existing methodology and analytical techniques in order to contribute to the improvement of the usefulness of present accident statistics. The problems facing O.E.C.D. member countries seemed to be: driver performance and preparation and decision making; fatalities and young drivers; pedestrian protection; safety campaigns; enhancing vehicle safety through study of the biomechanics and physical conditions of driving, such as lighting and winter driving, and improving highway safety through legal controls and enforcement measures, regarding alcohol, and drug use, and speed limits, specifically. The O.E.C.D. sponsored a symposium in which these topics were taken under consideration, and priori-

February 29, 1976

HS-017 268

ty was given to traffic safety. Four research groups have begun work to pursue activities in the areas of: driver education and training; driving in reduced visibility conditions due to adverse weather; hazardous road locations; their identification and elimination; and an ad hoc committee on the application of polarized headlights.

by B. E. Horn

Publ: Accident Analysis and Prevention v7 n2 p113-19 (Jun 1975)

1975 ; 12refs

Availability: See publication

HS-017 265

### **AN EMPIRICAL RELATION BETWEEN FATAL ACCIDENT INVOLVEMENT PER ACCIDENT INVOLVEMENT AND SPEED**

Data on the frequency of fatal and of injury accident involvement per accident involvement (fatality and injury rates), by speed, for five states, were compared. It was found that the fatality rate increased with speed in the same manner for speeds over 40 mph in all states considered. Below 40 mph large discrepancies were noted. Caution is urged against analysis of accident data where single and multiple vehicle data are not treated separately.

by H. C. Joksch

Publ: Accident Analysis and Prevention v7 n2 p129-32 (Jun 1975)

1975 ; 11refs

Includes German abstract.

Availability: See publication

HS-017 266

### **PHYSICAL EVIDENCE IN TRAFFIC ACCIDENT INVESTIGATIONS CAN MAKE A BIG DIFFERENCE**

Reasons are cited why physical evidence is valuable in motor vehicle accident investigations and how a safety professional may obtain and use it as one portion of his total accident investigation ability. In most cases, those persons involved in accidents do not know exactly what happened. Testimony of drivers, passengers, and spectators often conflict. The importance of observing accident debris, vehicle parts, and spilled liquids is stressed. The collection of evidence can be complicated when passing vehicles or feet alter liquid spills or when the vehicles are moved quickly after the accident. Also, vehicle contents and tire marks are discussed as sources of evidence. Despite the contradictions and discrepancies in the testimony of witnesses, it is concluded that both their statements and physical evidence are necessary to accident investigations.

by C. D. Attaway

Publ: Professional Safety v20 n8 p16-20 (Aug 1975)

1975 ; 4refs

Availability: See publication

HS-017 267

### **SOME TIPS ON SAFE MOTORCYCLING**

Information on safe motorcycle operation is presented. Proper passenger seating and behavior are discussed. The problems

and benefits of motorcycle driving in an urban situation are considered and some of the hazards that might be encountered are listed, including cars, bicycles and other non-motorized vehicles, pedestrians, birds, and oil patches. The need for an awareness of the mistakes of other drivers is emphasized. Certain problems encountered on turnpikes are discussed: high speeds, fatigue, problems at toll booths (handling money, oil slicks), exit speeds, and traffic jams. The unpredictable characteristics of country roads are mentioned. The special problems of night, wet weather driving and passing for motorcyclists are discussed in some detail and adequate safety reactions to emergencies are explained. The slipping hazards (wet spots, bridge grating, trolley tracks) of motorcycling, proper handling procedures in skids or slides, and safe handling of tire blow-outs are also discussed.

by Don Lehrbaum

Publ: Professional Safety v20 n8 p45-53 (Aug 1975)

1975

Availability: See publication

HS-017 268

### **REGARDING HIGHWAY SAFETY TODAY. STATEMENT BY THE SENIOR VICE PRESIDENT AND GENERAL MANAGER, LOSS PREVENTION DEPARTMENT, LIBERTY MUTUAL INSURANCE COMPANY, BEFORE THE SENATE COMMITTEE ON PUBLIC WORKS, SUBCOMMITTEE ON TRANSPORTATION, MARCH 26, 1974**

The highway safety problems that result from truck/passenger car interaction, and both existing and projected trucking regulations, are discussed. The accident record (1947-1972) of the trucking industry is examined and it is concluded that safety can be best improved by concentrating on driver selection, driver training, and the auditing of driver performance. Studies of the accident records of twin-trailer combinations compared to those of conventional tractor-trailers are presented. A study of the records of an interstate trucking company 1970-1973 shows that the accident frequency rate per million miles of twin-trailers (2.61) was less than that for tractor-trailers (3.36). Data on the accident rates of full-loaded twin-trailers on the Indiana Tollroad, the Ohio Turnpike, the Massachusetts Turnpike, and the New York Thruway are presented. All rates for full-loaded, twin-trailers were much less than those for single tractor-trailers. Load or gross weight does not appear to increase accident rates. Federal Motor Vehicle Safety Standard (FMVSS) 121 regarding improved braking and directional stability in emergency situations for trucks, tractors, trailers, and buses is discussed. Stopping distances for twin-trailers at various speeds with the proposed FMVSS 121-equipped units are compared with the stopping distances with conventional air-brake systems. At 60mph, the stopping distance under the new standard is reduced from 531 feet to 311 feet. The expansion of driver training facilities is emphasized. It is concluded that: truck fleets have accident rates that compare favorably with those of passenger car fleets; twin-trailer combinations have accident rates superior to lesser loads carried in single semi-trailer rigs; there is no evidence that twin-trailers are safer or easier to operate (the reverse appears to be true); driver failures are commonly found to be causes of serious accidents; weight restrictions are not necessarily required; and what is important are the improved design features of FMVSS 121 and operation of trucks by trained, competent drivers who are not

obliged to drive an excessive number of hours or at excessive speeds.

by Roger H. Wingate  
Publ: Professional Safety v20 n8 p40-4 (Aug 1975)  
1975 ; 6refs  
Availability: See publication

HS-017 269

### THE DILEMMA OF THE FLEET SAFETY PROFESSIONAL

The special problems of the fleet safety professional and how they can be effectively handled are discussed. Problems inherent in the trucking industry include: lack of professional training; equal rates of pay for beginners and veterans; lack of loyalty to company because of unions or the independent nature of the task; and lack of supervision at any point on the job. Fleet safety directors deal with people; the machines are generally out of their control. Methods for preventing accidents (safety awards, competent hiring procedures, improving the prestige of professional drivers, a knowledge of industrial safety practices and governmental regulations) are discussed. Attempts that have been made to certify safety professionals are considered. It is concluded that it is best for a fleet safety professional to begin his career with the thorough grounding of a proven safety education and then go on to learn his specialty.

by Frank M. Williams  
Publ: Professional Safety v20 n8 p35-8 (Aug 1975)  
1975  
Availability: See publication

HS-017 270

### FLEET SAFETY PLANNING AND DEVELOPMENT

The various measures taken by the safety professional in planning and implementing a sound program for fleet safety are discussed. The obligation of the employer to provide a safe and helpful work environment is considered. The first step that management should take to deal with the fleet safety problem is to hire a fleet safety professional. The responsibilities of the person filling this job are discussed. The driver-selection process (the application form, investigation of the applicant, employment interview, physical examination) and possible testing methods (intelligence, aptitude, interest, personality, proficiency, traffic and driving knowledge tests) are considered. The necessity for classroom, behind-the-wheel, real world, and defensive driver training along with competent supervision is stressed. The uses of incentive programs, fleet safety records, accident information and maintenance records are also discussed. The fleet safety director is the individual responsible for insuring the compliance with any standards that are set up.

by Robert M. Bieber  
Publ: Professional Safety v20 n8 p21-5 (Aug 1975)  
1975  
Availability: See publication

HS-017 271

### PEDESTRIAN/BICYCLIST ACCIDENT DATA SAMPLING AND ANALYSIS PROGRAM [PADSAP]: VOL. 1. MANAGEMENT SUMMARY. FINAL REPORT

by John W. Overbey, 2nd.; William W. Belew, 3rd.; Richard M. Helfand; James T. Massey; Victor D. Wenk  
MITRE Corp., 1820 Dolley Madison Blvd., McLean, Va. 22101  
Contract DOT-HS-357-3-721-1A  
Rept. No. MTR-6700 ; 1974 ; 39p  
For abstract, see HS-017 272 (vol. 2), HS-017 273 (vol. 3), HS-017 274 (vol. 4), HS-017 275 (vol. 5), HS-017 276 (vol. 6), and HS-017 277 (vol. 7).  
Availability: NTIS

HS-017 272

### PEDESTRIAN/BICYCLIST ACCIDENT DATA SAMPLING AND ANALYSIS PROGRAM (PADSAP): VOL. 2. FUNDAMENTAL STATISTICAL DESIGN. FINAL REPORT

The general statistical outline is presented for the Pedestrian/Bicyclist Accident Data Sampling and Analysis Program (PADSAP), undertaken to determine the cause of pedestrian and bicyclist accidents involving motor vehicles, and to develop countermeasures to reduce both the number and severity of such accidents. The PADSAP system and information requirements are discussed, which resulted from in depth interviews with Department of Transportation personnel (who are likely to be prime system users) and from an analysis of data collected in previous studies. Also discussed is the rationale involved in the selection of the data source and collection technique for supporting PADSAP. The statistical foundations of the survey are described in detail. The following system and information requirements are explained: user information requirements, and PADSAP data items (information on physical setting of accident, information common to each participant, information on motor vehicle, driver, pedestrian, and bicyclist, and actions and accident circumstances). The data source and data collection technique considerations are described. The survey design is discussed in terms of stratification, sample size, police agency selection and phased introduction, and police data collection (sampling plans for large city and large county strata). Also the following aspects of the estimation process are considered: notation; estimation formula for strata other than for the police strata; adjustments for the two large citystrata (high density and low density) and the large county strata (notation, estimation); combining the two components to obtain national estimate (quarterly and annual); estimation for subpopulations of interest; and procedures for handling missing data. Factors affecting the formulation of estimators are also discussed. It is concluded that the required information can be collected by police officers completing supplementary reports as part of their normal accident investigation duties.

by John W. Overbey, 2nd.; William W. Belew, 3rd.; Richard M. Helfand; James T. Massey; Victor D. Wenk  
MITRE Corp., 1820 Dolley Madison Blvd., McLean, Va. 22101  
Contract DOT-HS-357-3-721-1A  
Rept. No. MTR-6701 ; 1974 ; 86p 11refs  
See also HS-017 271 (vol. 1, Management Summary), HS-017 273 (vol. 3), HS-017 274 (vol. 4), HS-017 275 (vol. 5), HS-017 276 (vol. 6), and HS-017 277 (vol. 7).  
Availability: NTIS



HS-017 273

**PEDESTRIAN/BICYCLIST ACCIDENT DATA  
SAMPLING AND ANALYSIS PROGRAM [PADSAP]:  
VOL. 3. STATISTICAL DESIGN: SUPPORTING  
ANALYSIS. FINAL REPORT**

The analysis used to determine the stratification of the universe of police agencies (sample units) and to specify the sample size needed to support the objectives of the Pedestrian/Bicyclist Accident Data Sampling and Analysis Program (PADSAP) System is presented. The analysis methodology is examined in terms of: the estimated expected accidents per agency; a field sampling cost model (with labor, travel, per diem, printing, telephone/xerox/secretarial, and national promotion as component costs); the need for stratifying the sampling units; and the allocation technique (constraints on the allocation model). Stratification analysis and its results are discussed in terms of the analysis of alternatives and the sampling and stratification of the 26 largest cities in the country. Cost, sample size, estimate and precision trade-off curves are described. The method of selecting a sample size which satisfied the system objectives within the budgetary and administrative constraints is discussed. It was determined that 3,000 to 5,000 pedestrian and about 600 associated bicycle accidents would be sampled in six cities. About 350 police agencies were sampled. In addition, the following information is presented: accident data from 44 large cities; urban versus rural accident data; accident data from 67% of the nation's population; principle component analysis of the 26 largest cities; and a data processing and analysis cost model.

by John W. Overbey, 2nd.; William W. Belew, 3rd.; Richard M. Helfand; James T. Massey; Victor D. Wenk  
MITRE Corp., 1820 Dolley Madison Blvd., McLean, Va.  
22101

Contract DOT-HS-357-3-721-IA

Rept. No. MTR-6702 ; 1974 ; 108p

See also HS-017 271 (vol. 1, Management Summary), HS-017 272 (vol. 2), HS-017 274 (vol. 4), HS-017 275 (vol. 5), HS-017 276 (vol. 6), and HS-017 277 (vol. 7).

Availability: NTIS

HS-017 274

**PEDESTRIAN/BICYCLIST ACCIDENT DATA  
SAMPLING AND ANALYSIS PROGRAM (PADSAP):  
VOL. 4. SELECTION OF DATA ELEMENTS AND  
FIELD TEST RESULTS. FINAL REPORT**

The process of identifying data elements to be collected in describing pedestrian and bicycle accidents and techniques to be used in that collection for the Pedestrian/Bicyclist Accident Data Sampling and Analysis Program (PADSAP) is discussed. A review and analysis of the current data requirements of potential users of PADSAP was conducted to find out which data elements were being collected and which additional data elements needed to be collected. A field study conducted to test the validity of collecting the data elements by supplementing police motor vehicle accident reports and to test a supplementary questionnaire design is reported. A one-month field test was carried out in Miami and Dade County, Florida and in East Lansing, Michigan during March and April, 1974. The Bicycle and Pedestrian Accident Supplements designed for Michigan and Florida are shown along with the respective state accident investigation forms. The implementation of the field test (visits to selected agencies; distribution of supplement, collection of supplement, debriefing of investigating of-

ficers) is explained. Thirty-two accidents were reported in Florida and 43 in Michigan; the number of pedestrian and bicycle accidents was lower than originally projected. The supplements are evaluated in terms of which data terms are underreported, which items are marked differently on the state accident report than on the supplement, and which items are misinterpreted or otherwise checked incorrectly. The results of a debriefing of the police investigators in Miami at the completion of the field test is summarized. Specific conclusions and recommendations about the data items on the supplement, the questionnaire design and format, and the operational procedures for the survey are given. It is concluded that: all of the information recommended to be collected for PADSAP could be collected by police accident investigation or other trained investigators; and although a number of format changes are recommended, the general form of the supplementary questionnaire was adequate and reporting was very good.

by John W. Overbey, 2nd.; William W. Belew, 3rd.; Richard M. Helfand; James T. Massey; Victor D. Wenk  
MITRE Corp., 1820 Dolley Madison Blvd., McLean, Va.  
22101

Contract DOT-HS-357-3-721-IA

Rept. No. MTR-6703 ; 1974 ; 121p

See also HS-017 271 (vol. 1, Management Summary), HS-017 272 (vol. 2), HS-017 273 (vol. 3), HS-017 275 (vol. 5), HS-017 276 (vol. 6), and HS-017 277 (vol. 7).

Availability: NTIS

HS-017 275

**PEDESTRIAN/BICYCLIST ACCIDENT DATA  
SAMPLING AND ANALYSIS PROGRAM [PADSAP]:  
VOL. 5. DESCRIPTION OF SYSTEM OPERATIONS.  
FINAL REPORT**

A systematic description of the continuous operations of the Pedestrian/Bicyclist Accident Data Sampling and Analysis Program (PADSAP) is provided. The maintenance of the police agency frame and the selection of agencies to be sampled from the frame are discussed. The source of the police agency frame for data collection, the initial PADSAP frame processing, continuing frame maintenance and sample selection, and a sample analysis are considered. The field activities are described which directly relate to both gaining the participation of selected police agencies and ensuring their successful and continuing participation in the program. Included are general guidelines for: successfully enrolling selected agencies; developing supplementary forms to accurately record the necessary accident information; establishing effective form development and retrieval/submission procedures; and the initial screening of complete accident reports to permit early detection of incomplete or otherwise unacceptable forms. The manual and automated processes of converting data into a form amenable for producing survey estimates and the process of controlling regularity of data submitted from agencies are discussed. The system functional component of the processing involves the calculation of estimates of accident characteristic totals, ratios, and their associated variances by using the final basic accident file as input. The end-product is an estimate file and a set of intermediate reports. The estimation process, occurring once the number of sampled agencies reporting accidents during the sampling period approaches the number of selected agencies, is discussed. The reporting of estimates is described in terms of four specific user report formats: a one-way classification report for each category data element; a two-way classification report for various selected sets of two categories; and "ORI" categorization of accidents; and a non-

standard report for other combinations of data elements. The wide variety of statistical and quasi-statistical techniques that can be used for the analysis of data is mentioned.

by John W. Overbey, 2nd.; William W. Belew, 3rd.; Richard M. Helfand; James T. Massey; Victor D. Wenk  
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22101

Contract DOT-HS-357-3-721-1A

Rept. No. MTR-6704 ; 1974 ; 121p

See also HS-017 271 (vol. 1, Management Summary); HS-017 272 (vol. 2), HS-017 273 (vol. 3), HS-017 274 (vol. 4), HS-017 276 (vol. 6), and HS-017 277 (vol. 7).

Availability: NTIS

HS-017 276

**PEDESTRIAN/BICYCLIST ACCIDENT DATA  
SAMPLING AND ANALYSIS PROGRAM [PADSAP]:  
VOL. 6. DATA ANALYSIS PROCESSES**

A review and discussion of related techniques which might be useful in the analysis of the Pedestrian/Bicyclist Accident Data Sampling and Analysis Program (PADSAP) are presented. The descriptive or enumerative aspects of PADSAP are considered. Data descriptors and selected computer routines capable of producing these descriptors are presented. The analytical needs of PADSAP are also considered. The exact methods for various tests of totals and tests of the homogeneity of proportions are discussed. Three different types of tests which might be applied to PADSAP data are considered (comparing two independent samples, univariate case, and multivariate case). A test of independence for the two-dimensional contingency table based on the use of the balanced half-sample replicate is presented. The analysis of multi-dimensional contingency tables is discussed. Although no methods in the area are directly applicable for data stratified cluster samples, technical breakthroughs appear imminent. The state-of-the-art is briefly outlined, because these techniques will be very useful when they are developed. The use of weighted least square regression with PADSAP data is described and two "ransacking" techniques are given.

by John W. Overbey, 2nd.; William W. Belew, 3rd.; Richard M. Helfand; James T. Massey; Victor D. Wenk  
MITRE Corp., 1820 Dolley Madison Blvd., McLean, Va.  
22101

Contract: DOT-HS-357-3-721-1A

Rept. No. MTR-6705 ; 1974 ; 109p 74refs

See also HS-017 271 (vol. 1, Management Summary); HS-017 272 (vol. 2), HS-017 273 (vol. 3), HS-017 274 (vol. 4), HS-017 275 (vol. 5), and HS-017 277 (vol. 7).

Availability: NTIS

HS-017 277

**PEDESTRIAN/BICYCLIST ACCIDENT DATA  
SAMPLING AND ANALYSIS PROGRAM [PADSAP]:  
VOL. 7. ADP SPECIFICATIONS. FINAL REPORT**

Computer program specifications for program modules required for the Pedestrian/Bicyclist Accident Data Sampling and Analysis Program (PADSAP) are presented. Where the specific programs require little design guidance, only the desired output is specified. In other cases, detailed program flow charts are included as guidelines for program development due to their complexity or their unique role in the system design. A functional description is presented of the are as in

which computer programs will be required (frame maintenance and sample selection, editing and data quality control, estimation and report generation, and data analysis). Specific requirements that must be met by the software (proper storage limitations, language requirements) are listed. Several supporting documents useful to the programmer in following the specifications are mentioned. Descriptions of the following computer programs required to support the PADSAP system are provided: sample selection program, edit program, the stratification program; report preprocessor program, estimation program, and report program. Only functional descriptions are given for other programs whose coding is straightforward.

by John W. Overbey, 2nd.; William W. Belew, 3rd.; Richard M. Helfand; James T. Massey; Victor D. Wenk  
MITRE Corp., 1820 Dolley Madison Blvd., McLean, Va.  
22101

Contract DOT-HS-357-3-721-1A

Rept. No. MTR-6706 ; 1974 ; 108p

See also, HS-017 271 (vol. 1, Management Summary); HS-017 272 (vol. 2), HS-017 273 (vol. 3), HS-017 274 (vol. 4), HS-017 275 (vol. 5), and HS-017 276 (vol. 6).

Availability: NTIS

HS-017 278

**AUTOMOBILE INSURANCE LOSSES. COLLISION  
COVERAGES. A COMPARISON OF RESULTS FOR  
1973, 1974, AND 1975 MODELS**

The results of six reports on collision coverage insurance loss experience by vehicle series for 1973, 1974, and 1975 models and comparisons between market classes (sub-compact, compact, intermediate, full size, luxury, specialty, and expensive specialty) and model years are presented. Variations in both frequencies and sizes of insurance claims under the coverage are reported. The following comparisons are made: claim frequency per 100 insured vehicle years, average loss payment per claim, and average loss payment per insured vehicle year by market class of vehicles, by model year, and by operator age group; exposure in insured vehicle years by market class; and relative market class exposure. The details of the sources, nature of the data, and the method of analysis (vehicle descriptions and identification, exposure, claim frequency, average loss payment, average loss payment per insured vehicle year, standardization procedure) are provided by an appendix. Very large increases were found in average claim size for 1975 models in all seven market classes as compared with totals for 1973 and 1974 inflating average loss payment per insured vehicle year. Also, increases in average loss payment and claim frequencies were found for 1975 models.

Highway Loss Data Inst., Watergate Six Hundred,  
Washington, D.C. 20037

Rept. No. RR-HLDI-A-3 ; 1975 ; 32p 8refs

Availability: Corporate author

HS-017 279

**HUMAN RESPONSE TO WHOLE-BODY VIBRATION:  
AN EVALUATION OF CURRENT TRENDS**

It is argued that attention in psychophysical research should be directed away from experiments in which semantic labels are used to classify the intensity of vibration, and towards experiments which are designed to develop a ratio scale relating subjective and physical magnitudes. The use of fractionation procedures, particularly halving, in preference to magnitude

estimation procedures is encouraged. Recent developments are discussed and the following reasons for the above recommendations are derived: grave doubts have been expressed in a previous study (1968) concerning the validity of magnitude estimation procedures; it seems that magnitude estimation data of whole-body vibration are curved when plotted on log-log coordinates; and such difficulties appear to be avoided in a halving procedure, where there seems to be no curvature in the data. Plots of data from the halving technique and the magnitude estimation procedure are presented. A brief outline is given of magnitude estimation experiments (12 subjects responded to stimuli through seven intensity levels per series of vibration tests and at three series of each frequency) and halving experiments (12 subjects responded to different variable vibration by adjusting them until they were felt to be half of a previously experienced standard vibration).

by Maurice L. McCullough; Michael J. Clarke  
Grant SRC-BSR-7005

Publ: Human Factors v16 n1 p78-86 (Feb 1974)  
1974 ; 10refs

Supported by the Science Res. Council of Great Britain.  
Availability: See publication

HS-017 280

**VA [VETERANS ADMINISTRATION] STANDARD  
DESIGN AND TEST CRITERIA FOR SAFETY AND  
QUALITY OF SPECIAL AUTOMOTIVE DRIVING  
AIDS (ADAPTIVE EQUIPMENT) FOR STANDARD  
PASSENGER AUTOMOBILES**

Safety standards for special automotive driving aids for handicapped drivers, other than those provided by the automobile manufacturer, are presented. The following applicable document are discussed: Federal Motor Vehicle Safety Standards (FMVSS's 101, 105, 107, 124, 201, 203, 302); and the Society of Automotive Engineers (SAE) standards are recommended practices (J575 for lighting devices and J556 for automobile wiring). Tentative Veterans Administration (VA) standards are considered. Among the major components to be tested in VA qualification tests are: linkages, terminal brake and accelerator connectors, control levers, attachment hardware, and accessories (dimmer switch, horn button, and other special equipment). The VA standards regarding the following are presented, along with specifications and proper testing methodology; material strength; corrosion resistance; fasteners; electrical components and wiring; sharp edges and projections; conventional use of a motor vehicle; the neutral position of the control system; acceleration and brake motion; restriction of accelerator by hand controls; installation of components; certification; installation instructions; use instruction; sampling and inspection by the manufacturer; identification; warranty; claims made; distributors of equipment; static testing; fatigue life cycling; resistance to vibration; and laboratory simulators.

Veterans Administration, RCP-153, 252 Seventh Ave., New York, N.Y. 10001  
Rept. No. VAPC-A-7505-8 ; n.d. ; 17p  
Availability: Corporate author

HS-017 281

**1973 WINTER TEST REPORT. COMMITTEE ON  
WINTER DRIVING HAZARDS TRAFFIC**

**CONFERENCE, NATIONAL SAFETY COUNCIL,  
STEVENS POINT, WISCONSIN [JANUARY 29 TO  
FEBRUARY 9, 1973]**

Tests conducted on snow and ice covered surfaces (graded area, flooded and frozen, and an airport runway) in 1973 to evaluate various equipment, design features, accessories for motor vehicles, and various driving techniques are reported. The following test objectives were selected: stopping and stability performance of a tractor semi-trailer equipped with anti-wheel-lock device; braking distance tests of a 3-axle straight truck to establish a correlation with air and ice temperature and other variables; pulling ability of radial tires in conventional tread patterns as compared with snow tires in snow; performance of tire chains equipped with swivel hooks versus conventional chains; stopping performance of elastomeric chains compared to conventional chains; effect of salt application on coefficient of friction of ice covered surfaces; control and control recovery comparison of snow tires and studded snow tires; controlled stops on ice comparing neutral versus in-gear braking; and driver education workshops. The following vehicles and equipment were used: a Chevrolet sedan; a Ford LTD sedan; a friction trailer; two 3-axle straight trucks; a 3-axle Peterbilt tractor and tandem axle Fruehauf flatbed semi-trailer with anti-lock brakes; two tire-traction vehicles; and a variety of 4-door sedans for use in the driver education program. The basic ice courses were a straight ice pad 1,000 feet long and 250 feet wide and an ice circle with a 200 foot radius. For specific purposes, more restrictive courses were laid out on these surfaces. It is concluded that: a good relationship is established between locked wheel stopping distance and ice surface temperature for 3-axle vehicles with gross loaded weights of 38,720 pounds and a fair relationship for those partially loaded to 28,360 pounds; in terms of reduction of ice stopping distance, swivel hook chains provide much improvement over the use of regular tires, but not as great as V-bar reinforced chains; elastomeric chains provide some traction assistance on ice, but even with the X-device attached it is only half the traction advantage of V-bar reinforced chains; if ice thickness is one-eighth inch, salt application at a rate of about 700 pounds per two lane mile at 21°F air temperature will cause melting and elimination of ice within three hours; the use of studded snow tires on the rear wheels of a passenger vehicle provides significant benefit in rear-end skid recovery capability during a transient lateral maneuver; in panic situations, ice stopping is not affected by the car's gear position (in or out), but, in braking at low speeds, an automatic drive automobile with a fast idle may prove incapable of making the maneuver if the vehicle is left in gear; and the 1973 driver education workshops attended by 60 people, appears to have been highly successful.

National Safety Council, Com. on Winter Driving Hazards  
1973 ; 83p  
Availability: Corporate author

HS-017 282

**BIOKINETICS OF IMPACTS. PROCEEDINGS OF  
THE INTERNATIONAL CONFERENCE,  
AMSTERDAM, HOLLAND. JUNE 26-27, 1973**

A series of reports, representing part of a program for international coordination and cooperation in research on the biokinetics of impacts, is presented. The following aspects of the epidemiology of injuries are considered: frequency and severity of occupant injuries in different types of accident im-

pacts; injury patterns according to crash configuration; traffic accidents and injury evaluation based upon a coordinated data collecting system; analysis of fatal car crashes in which the victim was wearing a seat belt; fatal traffic accidents in Medellin, Colombia; clinical causes of death in different categories of road user; human tolerance to abrupt deceleration in water; injury causes and severity; a 15-year study of traffic accidents and injuries in the south of France; and the epidemiology of head injury. Collision characteristics and accident studies are reported in terms of: accident and collision characteristics; a video tape system for on the spot accident recording; a proposed method of classification for crash severity; the type, location, and severity of injuries in relation to the accident situation and severity of damage; field accident damage as a basis for crash tests; international data on traffic accident configuration and associated injuries; and passenger car pedestrian dummy collision experiments. Injury tolerances are studied and reported as follows: head injury tolerance to direct impact; prototypes of head injuries (application to animal experiments); experimental trauma of occipital impacts; model of direct closed head impact; motion of the brain at a suddenly applied rotation of the skull; head and spinal injury tolerance with no direct head impact; correlative pathology and biomechanics of craniospinal injuries; effect of seat back stiffness and collision severity on dynamic head behavior during whiplash; load capacity of the neck and base of the skull in indirect trauma; engineering-medical analysis of fatal and non-fatal head injuries of helmeted motorcyclists; effect of a protective device in head injury reduction; thoracic tolerances; chest fractures; injury protection offered by some energy absorbing steering systems; soft tissue injuries and injury tolerance levels; the mechanism of cortical bridging vein rupture; tolerance levels in blunt abdominal trauma; eye injury in traffic accidents; extremity injuries. A report on energy damage and countermeasure strategies is also presented.

International Res. Com. on Biokinetics of Impacts  
1973 ; 514p refs  
Includes HS-015 012--HS-015 051.  
Availability: Corporate author

HS-017 283

### FORD AUTO/EMISSION DRIVER SYSTEM

The Ford Auto/Emission Driver System automates the driving of a test vehicle on a chassis dynamometer while it is undergoing exhaust emission testing. The system drives the vehicle through the 1372s Environmental Protection Agency urban dynamometer driving schedule associated with exhaust emissions testing. The system controls vehicle speed by actuating the accelerator and brake pedals directly and also shifts the transmission if the vehicle is equipped with a standard transmission. Solid-state electronics control the high response, servohydraulic actuators in the mechanical console which in turn are interfaced to the vehicle controls via flexible mechanical push-pull cables. The system is portable, self-contained and is easy to install and operate. The system is consistently more repeatable and smoother than the best human driver, based on several empirical parameters. A comprehensive test program is underway to evaluate the reliability, accuracy and repeatability

of the system. Future development will include provisions for driving experimental test vehicles with poor driveability.

by R. T. Gryce  
Ford Motor Co., Product Devel. Group  
Rept. No. SAE-741007 ; 1974 ; 12p  
Presented at the Automobile Engineering Meeting, Toronto, Canada, 21-25 Oct 1974.  
Availability: SAE

HS-017 284

### DRINKING-DRIVING BEHAVIOR OF YOUNG MEN IN RELATION TO ACCIDENTS

To determine the role of drinking in the accidents of young men, data were examined from a representative survey sample of 1670 young men in southeastern Michigan and from official accident statistics of 4 states for the time period 1968-1970. By age 20, over half the sampled men drank at least once weekly and drove at least once monthly after drinking. Drinking-driving behavior rose with increasing age among teenage males. The percentage of young men in alcohol involved crashes, however, was low. It was found that alcohol was involved in 3-8% of all crashes of 20 year olds. The more severe the crash, the more frequently was alcohol involved, with 30% reported as drinking before fatal crashes, as compared to 6% reported in noninjury crashes. Nondrinking crashes were found most frequently for the 18-20 year olds, where as alcohol involved crashes were most numerous about age 22-24. After lowering the drinking age to 18 in Michigan, an increase in fatal crashes for ages 18-19 was not observed, contrary to expectation. From these data it was concluded that young men under 21 drank freely and drove occasionally after doing so, though most of them drove carefully after drinking. The proportion who had alcohol-involved accidents was far lower than the proportion who drank regularly, or who drove after drinking.

by Donald C. Pelz; Thomas L. McDole; Stanley H. Schuman  
Grant Ref: NIH-MH-21160; NIH-MH-21276  
Publ: Journal of Studies on Alcohol v36 n7 p956-72 (Jul 1975)  
1975 ; 17refs  
Sponsored in part by the Motor Vehicle Mfgs. Assoc.  
Availability: See publication

HS-017 285

### CONTACT TEMPERATURE OF A SKIDDING TIRE

The rate of heat generation in the contact patch of a skidding tire is high. An approximate solution is derived for the interface temperature and the rate of heat flow into the tire. Results show that after a fraction of a second essentially all the generated heat flows into the pavement and the interface temperature has reached a steady state. This temperature depends primarily on pavement properties. It is suggested that the same principles present in the case of a skidding tire can be applied to a tire in severe braking, cornering or traction, where the tire is slipping relative to the pavement.

by R. R. Hegmon  
Publ: Wear (Lausanne) v33 n1 p17-23 (Jun 1975)  
1975 ; 8refs  
Availability: See publication



HS-017 286

**CARPOOLING: STATUS AND POTENTIAL. FINAL REPORT**

Findings of studies conducted to analyze the status and potential of work-trip carpooling as a means of achieving more efficient use of the automobile are presented. Current and estimated maximum potential levels of carpooling are determined, as well as analyses revealing characteristics of carpool trips, incentives, impacts of increased carpooling, and issued related to carpool matching services. National survey results indicate the average auto occupancy for urban work-trip is 1.2 passengers per auto. This value, and average carpool occupancy of 2.5 have been relatively stable over the last five years. An increase in work-trip occupancy from 1.2 to 1.8 would require a 100% increase in the number of carpoolers. A model was developed to predict the maximum potential level of carpooling in an urban area. Results from applying the model to the Boston region were extrapolated to estimate a maximum nationwide potential between 47 and 71% of peak period auto commuters. Maximum benefits of increased carpooling include up to 10% savings in auto fuel consumption. A technique was developed for estimating the number of participants required in a carpool matching service to achieve a chosen level of matching among respondents, providing insight into tradeoffs between employer and regional or centralized matching services. Issues recommended for future study include incentive policies and their impacts on other modes, and the evaluation of new and ongoing carpool matching services.

by Donald C. Kendall  
Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142  
Rept. No. DOT-TSC-OST-75-23 ; 1975 ; 120p 11refs  
Rept. for Oct 1973-Jul 1974.  
Availability: NTIS

HS-017 287

**A COMMUNICATION-LINK APPROACH TO ACTUATION OF GRADE-CROSSING MOTORIST-WARNING SYSTEMS. FINAL REPORT**

An analysis to determine the basic feasibility and practicality of microwave usage for signal activation of grade-crossing motorist-warning systems was carried out at the Transportation Systems Center. Special attention was given to train detectors, microwave-propagation aspects, use of solar power, and radar train detection. As the fundamental means of warning activation, radar was found to be costly when meeting the requirements of very low false alarm rate and zero train-detection failures, within the constraints of high reliability, fail-safe operation, infrequent operation, infrequent and low-cost maintenance, and insensitivity to harsh environment. Radar may offer greater promise when used merely to provide constant warning time. With a microwave communication link, it was found that installation and maintenance at downtrack locations can be reduced to a low level. System malfunction can generally be distinguished from train presence, and the electronic complexity, basic expense and reliability of the equipment are comparable to conventional systems. Estimated costs

in 1972 dollars showed a total reduction of 16 percent for the system.

by John B. Hopkins; Robert Abbott; F. Ross Holmstrom; Edward F. White; A. Timothy Newfell  
Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142  
Rept. No. FRA-OR and D-75-80; DOT-TSC-FRA-75-7 ; 1975 ; 110p 7refs  
Rept. for July 1971-Jun 1973.  
Availability: NTIS

HS-017 288

**SHOULDER HARNESS USAGE IN THE POPULATION OF DRIVERS AT RISK IN NORTH CAROLINA**

Shoulder harness usage rates based on observations of vehicles in North Carolina in the summer of 1971 are reported. Tabulations of usage rates based on 19,333 observations are presented on a variety of demographic and environmental factors. A model of usage patterns is developed using a method of analysis of categorical data by linear models. The clusters derived with the highest predicted usage rates (33.3%) were foreign car drivers from out-of-state on Interstates, mature and older white male out-of-state drivers of foreign cars on rural non-interstate roads and young white male out-of-state foreign car drivers on rural four-lane divided highways. Values of variables which most consistently positively influenced usage rates were rural areas, foreign cars, road size, and male drivers. The overall usage rate is 4.8 percent with the males' rate being 5.4 percent and the females' rate being 3.2 percent. The influence on usage rate of 3-point versus 4-point shoulder harness systems in United States cars is examined with no real difference demonstrated. The effect of driver's shoulder harness usage patterns on right front passenger usage is discussed, and a usage rate of 51.1 percent for passengers whose drivers were wearing shoulder harnesses is reported.

by Jean L. Freeman; William W. Hunter; Gary G. Koch; John H. Lacey  
University of North Carolina, Hwy. Safety Res. Center, Chapel Hill, N.C.  
1975 ; 115p 18refs  
Supported by the Government's Hwy. Safety Prog. and a grant from the Inst. of General Medical Sciences.  
Availability: Corporate author

HS-017 289

**PERFORMANCE REQUIREMENTS FOR SNOWMOBILE LIGHTING SYSTEMS**

An experimental study was undertaken in order to define performance requirements for snowmobile headlamp systems related to collision avoidance capabilities. Field measurements of seeing distances with various alternative headlamp systems were made by means of photometric analyses of the headlamp output. Six snowmobiles were used, of which three were battery equipped for electric start, and three were manual start. Two of the 6 vehicles had a double headlamp system. Where possible, tests were run on the same evening in order to minimize variations in lighting conditions. The following performance criteria for snowmobile headlamps were required in order to assure maximum lighting effectiveness; headlamp mounting position should be as high as possible, out front, with no obstructions; ideal headlamp candela output is about 12,000 candela if proper beam geometry is observed; headlamp

beam geometry should be evenly dispersed with no localized hot spot; headlamp color should be yellow; output voltage should be compatible with the required voltage of the lamps; headlamp adjustment should be accessible with the lamp in operating position, allowing for both vertical and horizontal adjustment; and snowmobile visibility to oncoming vehicles should be accomplished by placing reflectors and tail lamps as high as practical on the snowmobile, so as not to be covered by snow.

by D. E. Givogue  
Hovey and Assoc., Ltd., Ottawa, Ont, Canada  
Contract 95128  
Rept. No. CR-7402 ; 1974 ; 30p  
Sponsored by the Canadian Ministry of Transport.  
Availability: Ministry of Transport, Road and Motor Vehicle  
Traffic Safety Branch, Ottawa, Ont., Canada

HS-017 290

### A STUDY OF RECREATIONAL SNOWMOBILE STABILITY

The tendency for recreational snowmobiles to suffer from rollover instability was investigated by examining the vehicle's behavior during skid-pad, serpentine and ramp test maneuvers. The snowmobiles utilized in the program were: a 1973 Raider; a 1973 Polaris Colt SS; a 1972 Evinrude Bobcat; a 1971 Mercury; and a 1971 Evinrude Bobcat. Snowmobile operators were required to wear restraint harnesses devised from automobile seatbelts. The following conclusions, as they would apply to an unskilled snowmobile operator running a vehicle on a firm, flat surface were presented: a twin track vehicle is more stable at higher speeds, than a single track vehicle; a standard single track vehicle cannot be expected to negotiate a 24 foot radius turn in excess of 10 miles per hour, a twin track vehicle up to 13 miles per hour; a standard single tracked vehicle cannot be maneuvered through a 30 foot slalom course in excess of 20 miles per hour without losing control; there is no evidence to suggest that a Christensen-Wulff steering system provides any better control than a standard steering system; single-track vehicles with standard steering and without shock absorbers at the skis can become unstable at speeds in excess of 20 mph when an obstacle is only 2 inches in size; the twin track system design was judged, after limited testing, to be the least prone to roll-over instability; vehicles not equipped with shock absorbers at the skis generally become extremely hazardous to operate at high speeds if an obstacle 5 inches or larger is struck; and there is evidence to suggest that minor changes to the shape of the skis could significantly reduce the probability of vehicle roll-over when encountering an obstacle.

by James A. Newman  
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Ottawa, Ont., Canada  
Contract S3264-7-1  
Rept. No. CR-7401 ; 1973 ; 48p  
Sponsored by the Canadian Ministry of Transport.  
Availability: Ministry of Transport, Road and Motor Vehicle  
Traffic Safety Branch, Ottawa, Ont., Canada

HS-017 291

### A SECOND EVALUATION OF SNOWMOBILE SAFETY (DEUXIEME EVALUATION DE LA SECURITE DES MOTONEIGES)

The findings of a comprehensive field test program performed on recreational snowmobiles during the winter of 1972-1973 to determine their performance as related to operating safety are reported. The results are compared to a program, carried out during the winter of 1970-71, in which the same test procedures were used. Tests were conducted on 10 snowmobiles to determine the following characteristics: braking ability; turning ability; (5 foot swerve); turning ability (90° turn); noise level; suitability of lighting; and cold starting ability. In addition, general operation over a cross country course gave information on the following parameters: cross country performance; fuel and oil consumption; general durability and safety; and maintenance requirements. Snowmobiles were operated in a wide range of snow and weather conditions. In braking tests, the "fifth wheel" pacer vehicle was used to establish initial speed before braking. Measurements of the distance required to swerve 5 feet to the side were made for 10, 20, 30, and 40 mph on packed snow and for 10, 20 and 30 mph on undisturbed snow. Ninety degree turn tests were performed at 10 and 20 mph, although only three of the vehicles could make the turn at 20 mph. Noise level was measured with a sound level meter placed 50 feet from the line of travel and at 90° to it. An automobile was parked directly parallel to the line of travel of the snowmobile in light measuring tests conducted at night, with lights on, and a 20 mph approach speed. In cold starting tests, snowmobiles were kept overnight in an unheated building and filled with cold fuel/oil mixtures. Cross-country operation (100 to 150 miles per vehicle) provided an opportunity to evaluate hand controls, engine transmission shielding, brake lights, and fuel and oil consumption. It is concluded that: there has been appreciable improvement in snowmobile safety by the addition of "kill buttons," hi-lo lighting control, and brake lights; brake levels and throttle controls have been improved; night visibility has been improved; there has been no significant improvement in overall snow mobile performance in braking, swerving and turning; the same noise levels were experienced with these vehicles as in the last program; and snowmobiles may never be improved to the point that they are safe for public roads used by other vehicles.

Hovey and Assoc., Ltd. of Ottawa, Canada  
Rept. No. CR-7403 ; 1974 ; 43p  
Text also in French. Supported by the Canadian Ministry of Transport.  
Availability: Ministry of Transportation, Road and Motor Vehicle Traffic Safety Branch, Ottawa, Ont., Canada

HS-017 292

### HITCH AND STABILITY PROBLEMS IN VEHICLE TRAINS [MULTI-TRACTOR AND TRAILER COMBINATIONS]

Hitch and stability problems which arise in the operation of truck trains were studied through extensive consultations with users of such equipment and through a review of related published literature. It was found that instabilities in vehicle trains occur in two general forms: weaving and swaying of the entire vehicle train moving at constant velocity; and jackknifing caused by tire skid at one or more axles resulting from brake application. Users of trains state that the most important factor in safe operation is the use of experienced drivers.

Weaving and swaying of trains can result from improper driving techniques, or from vehicle factors, or a combination of the two. Two important conclusions were made: there is a lack of fundamental knowledge of the design and operating factors which govern the operation of vehicle trains; and there is no way of predicting with confidence and accuracy, the hitch forces and hitch strengths required in the operation of vehicle trains.

by E. C. Mikulcik  
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Calgary, Alta., Canada  
Contract S3261-46 (TSRV)  
Rept. No. CR-7502 ; 1973 ; 43p 12refs  
Sponsored by the Canadian Ministry of Transport.  
Availability: Ministry of Transport, Road and Motor Vehicle  
Traffic Safety Branch, Ottawa, Ont., Canada

HS-017 293

## WRONG-WAY MOVEMENTS ON DIVIDED HIGHWAYS

A study of wrong way accidents is reported utilizing the accident records of divided highways in Indiana for 1970-72 as a data base. The ninety-six accidents studied were examined according to: numbers and locations; types and severity; times and dates; environmental conditions; age of drivers involved; sobriety of drivers involved; and fatigue of drivers involved. Field investigations of the accident areas were conducted and data collected on the road and area characteristics and road information systems nearby. Causes of the wrong-way movements were identified and preventive measures were developed. It was found that: 27 of the accidents had one or more fatalities, 29 had one or more injuries, and 40 caused property damage; 37 occurred on fully-controlled access highways, accounting for 17 of the fatalities; wrong-way accidents occur most frequently on Fridays and weekends between 6:00 pm and 4:00 am (only 26% during daylight); drivers tend to be drunk, older, and driving late at night and fatigued (only 31% were not influenced by one or more of these factors); wrong-way movements tended to originate from areas with low land-use density and false places at times of low traffic volume and low visibility; signing at accident sites was generally good; the use of channelizing islands and curbs appears to be a useful design element for reducing such accidents; and useful modifications included channelization at diamond and parclo interchanges and raising the crossroad elevation at divided highway intersections and directional driveways.

by Peter N. Scifres; Roy C. Loutzenheiser  
Purdue Univ., Joint Hwy. Res. Proj., West Lafayette, Ind.  
Rept. No. JHRP-13-75 ; 1975 ; 49p 5refs  
In cooperation with the Indiana State Hwy. Commission. See also HS-014 616.  
Availability: Corporate author

HS-017 294

## SOME PHENOMENA WHICH CONTROL SULFURIC ACID EMISSION FROM AUTOMOTIVE CATALYSTS

With the use of a simulated exhaust system, the sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) and sulfur dioxide (SO<sub>2</sub>) emission from a monolith noble-metal oxidation catalyst is measured. Propylene was used as the artificial exhaust gas. A batch method of analysis was used for the 60 minute experiment. It was found that the

storage rate of sulfur onto an initially sulfur-free catalyst decreases to a few percent of the sulfur rejection rate within three to four hours. The amount of sulfur on the catalyst when the catalyst is in equilibrium with 20 parts per million sulfur in the gas phase varies between 0.3 weight percent of the catalyst at about 400°C to about 0.1 weight percent at 600°C. The sulfur can readily desorb from the catalyst if the gas phase sulfur content is lowered or if the catalyst temperature is increased. It was also found that the conversion of SO<sub>2</sub> to H<sub>2</sub>SO<sub>4</sub> reaches thermodynamic equilibrium at 400-500°C, corresponding to a small V8 engine at a 20 mph cruising speed. In the simulated exhaust system without a catalyst, propylene, propane and hydrogen, which are present in automobile exhaust, reduce H<sub>2</sub>SO<sub>4</sub> to SO<sub>2</sub>. This reduction appears to be a homogenous reaction.

by Robert H. Hammerle; Mati Mikkor  
Ford Motor Co.  
Rept. No. SAE-750097 ; 1975 ; 15p 9refs  
Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 295

## STEEL CAPACITY AND CRITICAL RAW MATERIALS: AN OUTLOOK FOR GROWTH

The current 1980 estimated domestic steel production is discussed. The availability of the essential raw materials that may hinder or delay expansion is presented. Included are availability outlooks for iron ore, zinc, nickel, ferro alloys, refractories, electrodes, fossil fuels, electric power and ferrous scrap. Emphasis is placed on those commodities that are now in short supply or may be between now and 1980. Figures are supplied on: row steel production by type of furnace and grades; domestic steel shipments; 1969 iron and steel inventory; estimated scrap supply/demand balance in the United States (1973, 1975, 1980) and supply/demand capacity (1975, 1980); and comparison of domestic scrap consumption with pig iron production. Graphs are provided for the following: total steel product shipments in the United States (U.S.), domestic and import; relation of U.S. zinc production to total vehicle production; U.S. slab zinc consumption (for brass products, galvanizing, die casting, and other uses); world zinc production and consumption (plant capacity, mine production); nickel production (actual production, calculated future production); and scrap consumption versus total metallics (scrap plus pig iron). Outlooks for essential raw materials include: the iron ore supply/demand problem will ease by 1980; long term zinc supply needs will be met; nickel supply may ease in 1975 and should remain in balance for 10 years; ferro alloys supply/demand problems should improve by 1977; refractory expansion is needed or lower-grade refractory products may have to be used; a balanced electrode supply/demand should come by 1977; fossil fuels should be available to meet needs although there will be interruptions in flow; and scrap shortages will continue to exist unless exports are limited to only such tonnages as are clearly surpluses.

by Albert W. Connar  
Bethlehem Steel Corp.  
Rept. No. SAE-750098 ; 1975 ; 16p 16refs  
Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 296

HSL 76-02

HS-017 296

### POTENTIAL FOR METHANOL AS AN AUTOMOTIVE FUEL

The rationale for considering methanol as an automotive fuel is presented along with some experimental data supporting the contention that methanol has a number of advantages over gasoline (as well as some drawbacks). Economy, emissions, and performance for an engine operating on methanol are compared with the same engine operating on gasoline. The engine (a standard 1973 Ford 302-CID-V-8 with 2-barrel carburetor) was run on a dynamometer test stand at steady state conditions, simulating 30, 50 and 70 mph operation at both road and maximum power. The advantages of methanol (clean burning, free of sulfur, trace metals, and polynuclear aromatics) and its drawbacks (low heat of combustion per unit volume or weight) are discussed. It was found that: lean methanol engine operation gave improved tail pipe emissions and better Btu efficiency than gasoline; nitrogen oxides emissions are significantly greater for gasoline than methanol at road load and maximum power; at maximum power carbon monoxide emissions are considerably less for methanol; unburned fuel emissions from methanol present problems in measurements and expression; and methanol consumption on a Btu/horsepower/hour basis shows some advantage over gasoline. It is concluded that numerous problems can be expected in retrofitting automobiles to use methanol but the task does not appear insurmountable and deserves consideration.

by R. M. Tillman; O. L. R. Spilman; J. M. Beach  
Continental Oil Co.  
Rept. No. SAE-750118 ; 1975 ; 8p 6refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 297

### SINGLE-CYLINDER ENGINE EVALUATION OF METHANOL-IMPROVED ENERGY ECONOMY AND REDUCED NOX [NITROGEN OXIDES]

A standard CFR single-cylinder engine with a variable-compression engine used in the octane rating of fuels and a single cylinder CLR oil test engine were used to test pure methanol, methanol/water blends, and isooctane as fuels. An exhaust emission and analysis system provided continuous monitoring of oxides of nitrogen, oxygen, carbon monoxide (CO) and unburned hydrocarbons. The complete instrumentation is explained. The general properties of methanol are compared to those of isooctane, and methanol/water octane ratings and methanol energy economy advantages are presented. The engineering development problems of a methanol-powered vehicle and the logistics of commercial application are discussed. It is concluded that: methanol provides an improved specific energy consumption relative to isooctane and to current unleaded gasoline; methanol's superior lean combustion characteristics provide a potential for high efficiency with very low CO and nitrogen oxides (NOX) emissions levels; methanol combined with water permits operation at much higher compression ratios, resulting in better specific energy consumption with no NOX penalty; methanol combined with large amounts of water (20%) permits operation at higher power density consistent with decreased NOX; no fundamental limitations have been found in actually realizing methanol's advantages; and,

though lack of supply will delay large-scale methanol use for at least a decade, research should be continued.

by W. J. Most; J. P. Longwell  
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Linden, N.J. 07036  
Rept. No. SAE-750119 ; 1975 ; 13p 23refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 298

### EXHAUST EMISSIONS, FUEL ECONOMY, AND DRIVEABILITY OF VEHICLES FUELED WITH ALCOHOL-GASOLINE BLENDS

The effects of blending methanol and ethanol (10%) with gasoline on two cars (1973, 1974) equipped with automatic transmissions and with 4,000 kilometers of normal driving experience using unleaded gasoline were investigated. At least two tests were run with a base unleaded gasoline and the blend to determine the effects on hydrocarbon and nitrogen oxides emissions, fuel economy, driveability, performance, and octane requirement. The ratio of each test value to the mean was calculated. Using these ratios from all tests (with gasoline, with blends, with vehicle modifications) a standard deviation was calculated and, multiplied by 100, the pooled coefficient of variation was formulated. Fuel economy was evaluated on the road under the following conditions: constant speed; level road cruises; three driving cycles to simulate business district, suburban, and highway driving; and various carburetors. Driveability was evaluated both on the road and on a chassis dynamometer. The time required for the engine to perform wide-open-throttle (0-129 km/hr) and part-throttle accelerations (97 km/hr to 129 km/hr) was measured. Road octane measurements were performed at a variety of speeds. Fourteen cars with good driving experience were tested with clear indolene and a 10% methanol-indolene blend as fuels to determine the same effects. It was found that: adding alcohol to gasoline with carburetor modifications decreased carbon monoxide emissions, volume based fuel economy, driveability, and performance; depending on carburetor's air-fuel ratio characteristics, hydrocarbon and nitrogen oxide emissions and road octane are either increased, decreased, or not affected; and these effects are explained by changes in stoichiometry, energy content, combustion temperatures, and detonation resistance caused by the addition of alcohol to gasoline.

by N. D. Brinkman; N. E. Gallopoulos; M. W. Jackson  
General Motors Corp.  
Rept. No. SAE-750120 ; 1975 ; 30p 29refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 299

### METHANOL AS AUTOMOTIVE FUEL. PART 1. STRAIGHT METHANOL

A study is presented of methanol as an automotive fuel using a single-cylinder research engine, a 1972 4-cylinder 122-CID (2,000 cubic centimeter) engine, and a 1972 8-cylinder 350-CID engine. Exhaust was analyzed for hydrocarbon (HC), carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), and nitric oxide (NO) content. Steady-state fuel economy and emissions data were



taken from the 350-CID engine operating on an engine dynamometer. It is concluded that: an engine can be operated at steady-state operating modes with methanol fuel at air-fuel ratios of up to 9.7 without misfire; for multicylinder engines, improvement over the air-fuel distribution typical of current conventional gasoline will be required with methanol before the full benefit of the lean-limit characteristics of methanol can be realized; level road, steady-state fuel economy for the 350-CID engine ranged from 10.8 miles per gallon at 30 mph cruise to 7.5 miles per gallon at 70 mph cruise; fuel economy at 50 mph cruise was about 5% higher for methanol than gasoline when compared on an equivalent energy input basis with the engine operated at comparable mixture strength for both fuels; CO emissions were the same for methanol and gasoline when they were at the same mixture strengths; HC mass emission at 50 mph cruise using methanol was about 77% of that using gasoline at stoichiometric air-fuel ratios; and NO emissions at 50 mph cruise using methanol was about 46% of that using gasoline at stoichiometric ratios.

by R. D. Fleming; T. W. Chamberlain  
Energy Res. and Devel. Administration  
Rept. No. SAE-750121 ; 1975 ; 13p 6refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 300

# METHANOL AS A MOTOR FUEL OR A GASOLINE BLENDING COMPONENT

Laboratory and road tests were conducted on various 1970 and 1971 cars to determine the effect of methanol fuel on octane, power, cold starting, vapor locking, cold start driveability, fuel economy, and exhaust emissions. The benefits of lean operation with methanol, required engine modification, water sensitivity of methanol gasoline blends, and the deterioration of the fuel system are discussed. It was found that: methanol is an effective octane booster (three unleaded gasolines were raised two to three octane numbers); cold starting is very difficult at low temperatures (a separate starting fuel system is required); adding 10% methanol to gasoline causes a large increase in front end volatility (much lighter gasoline blendings needed to prevent vapor locking in hot climates); 10% methanol caused deterioration in driveability because of methanol's "leaving" effect; and high concentrations of methanol require extensive intake system modifications, but offer emissions advantages. In addition, it was found that: methanol gives poorer fuel economy at all concentrations because of its low heating value; on an energy basis (miles per million Btu's), methanol addition to gasoline caused improvements in fuel economy; methanol showed only one emissions benefit, lower nitric oxides levels, under identical conditions; 14% lean methanol performed better than 5% lean gasoline (maximum for good driveability) in all emissions areas except unburned fuel in cold start tests and aldehydes; the water sensitivity of hygroscopic mixtures of methanol and gasoline requires a separate fuel distribution system (fuel storage must be protected from water absorption); and where methanol/gasoline mixtures contact lead, magnesium, aluminum, and some plastics corrosion and degradation problems occur. It is concluded that: methanol is not a useful fuel additive for existing unmodified cars; and the cost of manufacture and distribution in a separate system that overcomes the water

sensitivity problem will determine the extent of methanol's use.

by J. C. Ingamells; R. H. Lindquist  
Chevron Res. Co., Richmond, Calif.  
Rept. No. SAE-750123 ; 1975 ; 15p 8refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 301

# RACING EXPERIENCES WITH METHANOL AND ETHANOL-BASED MOTOR-FUEL BLENDS

Methanol and ethanol, which have been used widely, especially in blends, have possibilities as motor fuels. Specialized experience with alcohols as high performance racing fuels parallels World War I era results with substitute motor fuels. There are several types of practical operational problems indicated, especially in the areas of: water solubility, plastics solvent action, metal corrosion and galvanic effects, low air-fuel ratios and low calorific content, and high latent heat. Simply switching to alcohol-gasoline blends in conventional automotive fuel systems and engines is not as straightforward a matter as some tests seem to indicate. Modern day racing techniques for handling alcohols include: the anodizing and plating of nonferrous alloy fuel system and engine castings; using solvent-resistant plastics and corrosion-resistant metals, draining and flushing out of the fuel system and engine with hydrocarbon-fuel oil mixes after running; using alcohol-soluble synthetic lube oils; sealing and storage of fuel containers and tanks so as to reduce atmospheric moisture absorption; using higher energy ignition systems to better fire the "wet" alcohol fuels at high C.R.s; and nearly tripling and doubling the fuel system capacity.

by T. Powell  
Hofstra Univ.  
Rept. No. SAE-750124 ; 1975 ; 11p 35refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 302

# FEASIBILITY OF COOLING DIESEL ENGINES BY INTRODUCING WATER INTO THE COMBUSTION CHAMBER

The feasibility of total cooling a single-cylinder diesel engine by various methods of introducing water into the combustion chamber was investigated, including direct injection, manifold injection, and manifold induction. The effect on diesel cycle performance, fuel economy, combustion characteristics, cycle events, exhaust gas emissions, and engine wear were determined. An investigation of practical means was conducted providing for the total internal cooling of the engine to eliminate the need for jacket cooling. Design cooling parameters were determined to make the engine completely self-sustaining by providing for 100% recovery of internally injected cooling water. The following results were obtained: total cooling of diesel engines by direct water injection can be accomplished with increased power and better brake specific fuel consumption (optimum total cooling by direct water injection was accomplished over a wide range of water injection timings at water/fuel ratios of 2.9-3.7 with output power and

brake specific fuel consumption improved to 5-20%, respectively, over that with the standard jacket-cooled engine); the exhaust must be cooled to nearly 100°F at atmospheric pressure for 100% recovery of internally injected water used for cooling (total engine cooling by direct water injection is considered impractical for engines that must operate using fans and air-to-water radiators for cooling, while potential uses of direct water injection are marine and stationary engines and for spurt power applications); emissions are affected in an expected manner by the presence of injected water (nitric oxide is decreased, while hydrocarbons and carbon monoxide emissions tend to increase); when cooling the exhaust during water recovery tests, the condensate functions as a scrubber for some emissions; sulfur oxides are effectively scrubbed while nitric oxides, hydrocarbons, and carbon monoxide are not removed from the exhaust; water injection contamination of the lubrication oil varies from negligible to extreme, depending on injection quantity, timing and spray patterns; by aiming injected water at the piston head and not at the liner wall, and by keeping the oil above 212°F, the engine oil can be maintained in a dry condition; no severely stressed or damaged parts of the engine cylinder, piston, valves or rings were observed due to water injection operation. Difficulty was experienced in corrosive damage to bearings, cam and cam follower of the water injection pump caused by water leakage into the lower end of the pump. Injection of water contributed very little to combustion chamber deposits as observed upon disassembly of the engine.

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Army Fuels and Lubricants Res. Lab.; Army Tank  
Automotive Command  
Contract DAADO5-72-C-0053  
Rept. No. SAE-750129 ; 1975 ; 16p 12refs  
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Availability: SAE

HS-017 303

### DRAW BEAD DESIGN FOR DEEP PROFILES

Draw beads are used to produce deep-drawn parts in alloy 2036-T4 and to help control metal flow, as well as to prevent wrinkles and buckles in the side walls of a deep drawn shape without having to resort to excessively high hold-down pressure. Alloy 2036-T4 is stronger than most aluminum alloys used for deep-drawn parts, and therefore requires a greater than customary degree of control to obtain proper metal flow. This control is obtained through the use of draw beads. It is expected that most, if not all automotive panels can be formed with bead configurations customary in the automotive industry. A design, using a single bead, was used for drawing large pans nine and fourteen inches deep. Size of the piece part corner radius varied directly with depth of the draw. A suggested draw bead design applicable to deep draws based on a case history is presented. Experience has shown that this draw bead design provides control over the flow of aluminum alloy 2036-T4 as well as other aluminum and steel alloys having similar mechanical properties. All aluminum alloys require the application of a high quality nonstaining lubricant as an aid to formability and to help reduce die galling.

by Reinhardt Conrad  
Reynolds Metal Co.  
Rept. No. SAE-750130 ; 1975 ; 6p  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 304

### INVESTIGATIONS CONCERNING THE EMPLOYMENT POSSIBILITIES OF THE DIESEL-GAS PROCESS FOR REDUCING EXHAUST EMISSIONS, ESPECIALLY SOOT (PARTICULATE MATTER)

In an attempt to abate soot emissions, diesel fuel for a direct-injection, single-cylinder diesel engine was step-by-step replaced with natural gas. The gas was introduced into the intake system. As a result, soot emissions were decidedly improved and maximum power was increased. An undesirable secondary effect, however, especially at small loads, was shown in an increase in brake specific gas-diesel fuel consumption and an increase in emission of hydrocarbons and carbon monoxide emissions. Nitric oxide emissions did not change until high load levels. Exhaust gas recirculation and throttling were investigated as possible countermeasures. Both were capable of reducing the emission of poisonous gaseous exhaust components at high gas rates, without essentially increasing soot emissions. Also, higher part-load consumption could be reduced by these countermeasures. The application of the diesel-gas process for automotive purposes is possible at medium and full load, but at low part load no gas should be added to prevent increased carbon monoxide and hydrocarbon emissions. A convenient application for automotive engines presumes the availability of a small gas generator installed at the engine for converting liquid fuels to a combustible gas. Of straight-run fuels, diesel fuels are especially convenient due to their low octane number and favorable gasification properties.

by Herbert Tesarek  
Institut fuer Verbrennungskraftmaschinen, West Germany  
Rept. No. SAE-750158 ; 1975 ; 11p 6refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 305

### AN UNTHROTTLED GASEOUS FUEL CONVERSION OF A 2-STROKE DIESEL ENGINE

The feasibility of converting a conventional unthrottled 2-stroke diesel engine to gaseous fuel was investigated. Three types of engine design conversions were tested. The engine use for the development work was a DDA 3 cylinder, 71 in B displacement/cylinder engine with a 4-valve head. One cylinder was converted to run on methane fuel while the two remaining cylinders were run conventionally as a diesel to motor the experiment. The final design configuration was based on studies of two earlier designs, one of which was limited in power input, and the other produced relatively high unburned hydrocarbons under part-load operation. A 6 cylinder Detroit Diesel Allison 67-71 incorporated a pre-combustion chamber and a main chamber with a gas inlet valve in each chamber; modified pistons, camshafts and cylinder heads; and was run on a dynamometer, whereby performance and exhaust emissions could be measured. Fuel consumption for the 6V-71 conversion was high in comparison with the two earlier design engines. Exhaust emissions were also higher, a problem which appears to be associated with the fuel and/or air distribution system, resulting in cylinder to cylinder variations. Exhaust smoke for the 6V-71 is not visible and the odor, much like that of natural gas was not considered offensive. Noise level comparisons between the 6V-71 diesel and 6V-71 natural gas en-

gines showed that the noise level for the gas engine was approximately 50% lower than for the diesel. After 50 hours of endurance testing, the engine did not develop any serious mechanical problems or show any signs of unusual wear. The converted 6V-71 engine started easily, idled well, and ran smoothly through the full power and speed ranges. The 6V-71 engine conversion was quieter than the 6V-71 diesel. It is conceivable that the conversion could be installed in a bus and perform well; however, improvements are needed in fuel consumption along with a reduction in unburned hydrocarbons before any real consideration should be given to making actual conversions in the field.

by Thomas E. Ritter; Charles D. Wood  
Southwest Res. Inst.  
Rept. No. SAE-750159; 1975 ; 20p 6refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1974.  
Availability: SAE

HS-017 306

### THE GT-225--AN ENGINE FOR PASSENGER-CAR GAS-TURBINE RESEARCH

The need for an alternative low-emission engine for passenger cars has led to a re-evaluation of the gas turbine. A GT-225 engine was designed as a research tool to aid in making the evaluation. Factors which received special consideration in making design decisions included exhaust emissions, fuel economy and drivability. An extensive combustor development effort was undertaken to achieve low emissions. The engine has been installed in a test-bed vehicle to permit evaluation of emissions and other factors under actual driving conditions. Vehicle tests of the engine fitted with the low-emission combustor demonstrated the following emissions: 0.11 grams per kilometer (0.18 grams per mile) hydrocarbons; 1.2 grams per kilometer (2.0 grams per mile) carbon monoxide; and 0.23 grams per kilometer (0.38 grams per mile) nitric oxides. In addition, fuel economy competitive with that of conventional passenger cars at turnpike speeds, substantially improved throttle response in comparison with earlier heavy-duty turbine engines, and engine braking equal to that provided by the typical powertrain in today's cars, were demonstrated. Continued effort should be directed toward improvements in components, controls and engine design in order to further the potential of the gas turbine as an alternative engine for passenger cars.

by John S. Collman; Charles A. Amann; Charles C. Matthews;  
Richard J. Stettler; Francis J. Verkamp  
General Motors Corp.  
Rept. No. SAE-750167 ; 1975 ; 24p 47refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 307

### RELIABILITY ANALYSIS OF CATALYTIC CONVERTER AS AN AUTOMOTIVE EMISSION CONTROL SYSTEM

A reliability analysis, conducted by means of the failure mode effect analysis technique on the catalytic converter adopted in the 1975 Toyota models, is presented. A series of tests are conducted to determine the failure modes of a precious metal pelleted catalyst (damage intensity and correction factor).

Temperature characteristics in the converter and vehicle driveability results are discussed for testing under the following conditions: normal; one cylinder misfiring; two cylinder misfiring; whole cylinder misfiring; choke valve sticking, excessively rich mixture; carburetor flooding, excessively rich mixture; and fuel run-out. It is concluded that: converter melting is caused by ignition system component failures causing two cylinder or more frequent misfire; ignition system component failures causing cylinder misfire and choke component failures, causing slightly open choke valve sticking, have high potential for causing bed cracking or deformation; carburetor component failures; giving excessively rich mixtures, and fuel system and carburetor component failures causing insufficient fuel supply, can deteriorate the conversion efficiency of the catalyst; the warning system is ineffective to prevent converter melting; and the secondary air switching system has the potential to decrease thermal influence of component failures on converter damage and on deterioration of the catalyst performance.

by K. Matsumoto; T. Matsumoto; Y. Goto  
Toyota Motor Co., Ltd.  
Rept. No. SAE-750178 ; 1975 ; 12p 4refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 308

### DURABILITY TESTING OF STABILIZED RU [RUTHENIUM]-CONTAINING CATALYSTS

The durability testing of monolithic, stabilized ruthenate (Ru) catalysts on a laboratory bench set-up dynamometers, and vehicles is discussed. Post-mortem analysis of the durability-tested catalysts are presented showing the extent of stabilization. It is found that: under a relatively mild durability cycle, (10,000 miles) the first generation of stabilized Ru catalysts perform well, in tests of less than 300 hours; exposure of the catalysts to harsher conditions (25,000 miles) causes severe deactivation of the catalyst efficiency, due partly to incomplete stabilization; improved performance is achieved by subjecting a later version of the stabilized Ru catalysts to a less severe durability cycle; further improvement in the efficiency and the durability of catalysts can be achieved by tighter control of air-fuel ratios minimizing the lean and rich transients to the nitrogen oxides catalysts; sulfur and lead poisoning are detrimental to the catalysts; barium containing catalysts retain higher amounts of sulfur; and the first catalyst of a dual-bed system retain 20-30% lead. It is also found that the air-fuel ratio necessary for the highest net nitric oxide conversion efficiency shifts, for aged Ru catalysts, somewhat towards the rich side of the stoichiometry. It is concluded that, in spite of the significant improvements obtained by stabilization, the durability of the current Ru-containing catalysts is still inadequate for the achievement of the expected emission standard in present vehicle systems.

by H. S. Gandhi; H. K. Stepien; M. Shelef  
Ford Motor Co., Scientific Res. Staff  
Rept. No. SAE-750177 ; 1975 ; 11p 12refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

## DUAL CATALYTIC CONVERTERS

Development programs undertaken to determine the emission potential of dual catalytic converter systems, achieving optimum reducing and oxidizing efficiency from reducing catalysts, (in response to stringent 1978 nitric oxides (NOX) standards) are described and the durability of these new systems is determined. The dual systems were evaluated in automobiles with 350 cubic inch displacement engines, and carburetors modified to operate at the particular catalyst's optimum air-fuel ratio (from 13:1 to 14.5:1) and exhaust gas temperature range. Two basic converter systems were used in the program (one with two NOX converters in each exhaust downpipe and an oxidizing converter under the right front floor; and the other with a combined reducing-oxidizing package mounted at each exhaust manifold). During durability testing, the deterioration of the catalyst was monitored at 0, 2,000 and 4,000 and every 4,000 mile interval thereafter. A closed loop air-fuel ratio control incorporated into the testing is described and cost-benefit relationships are discussed. It was found that: dual catalyst system durability was poor; the maximum mileage achieved while still meeting federal regulations was 12,000 miles; and maximum NOX catalyst durability was 24,000 miles. It is concluded that: these systems may result in poorer fuel economy because of the additional spark retard required to reduce hydrocarbons to levels needed to achieve 50,000 mile durability; and system are complex and would require much more development to meet the requirements of the 1978 emission standards.

by S. L. Genslak; J. A. Zahorchak  
General Motors Corp., Engineering Staff  
Rept. No. SAE-750176 ; 1975 ; 11p 7refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

## GAS PHASE EFFECTS IN A MONOLITH CONVERTER MODEL

A steady-state, mass-transfer-limited monolith model is formulated to investigate analytically the effects of gas-phase phenomena on converter performance. Gas-phase reaction kinetics are included to demonstrate the significance of non-catalytic processes to overall conversion, especially at temperatures above 850° K. Developing boundary layers in the monolith channels are shown to increase the calculated conversions relative to conditions for fully developed, laminar flow. Substantially different conversion efficiencies are predicted for various hydrocarbon species because of the effect of component diffusivity on convective mass-transfer rates. The expression for the gas-phase oxidation of hydrocarbon indicates that carbon monoxide (CO) forms as an intermediate product. Experimental evidence of CO formation in conjunction with high concentrations of inlet hydrocarbons has been modeled with this partial oxidation reaction. Comparisons of the model calculations with other experimental results reveal important trends which are related to the gas-phase reactions. Over-prediction of the magnitude of the hydrocarbon conversion occurs because the mass-transfer-limited assumption is probably inapplicable to some hydrocarbon species. In addition to quantifying the effects of gas-phase phenomena, areas for additional research are identified: improvement of expressions for gas-phase kinetics, measurement of hydrocarbon spe-

cies distributions, and quantification of kinetic limitations for catalytic conversion in monoliths.

by David S. Dickey  
General Motors Corp., Res. Labs.  
Rept. No. SAE-750175 ; 1975 ; 16p 20refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

## THE IMPORTANCE OF SECONDARY AIR MIXING IN EXHAUST THERMAL REACTOR SYSTEMS

Improved mixing of exhaust gas and secondary air in the engine exhaust port are examined as a means of improving thermal reactor efficiency at less rich engine air/fuel ratios. Three air-injection systems (open tube, sparger tube, and timed injection) spanning a broad range of mixing capabilities are examined. Mixing characteristics are deduced from anemometry measurements of instantaneous secondary airflow, and emission performance of each system is generalized by a test program (measuring reactor outlet emissions at various air injection rates to identify the optimum reactor air/fuel ratio) employing four steady-state conditions (combination of two engine speeds and two exhaust flow rates). Mixing effects, port reactions with timed injection, and stable combustion with timed injection are discussed. It is concluded that: improving mixing of secondary air and exhaust gas in the engine port can substantially increase thermal reactor conversion efficiency; the secondary airflow required to obtain optimum conversion decreases as the air/exhaust mixing is improved; reactor conversion efficiency improves with increasing engine speed and decreases with increasing exhaust flow rate; moderate improvements in mixing and as much as 50% lower outlet carbon monoxide (CO) can be obtained by replacing conventional open-ended air injection tubes with sparger tubes; large improvements in mixing, and as much as 67% lower outlet CO, can be obtained by replacing low-pressure injection tubes with a high-pressure, times air injection system; significant CO oxidation in the engine port is obtained with timed air injection, markedly improving reactor performance in oxygen-deficient conditions; and although less effective than times injection, sparger tubes are more practical in terms of cost, complexity, and durability.

by Ronald J. Herrin  
General Motors Res. Labs.  
Rept. No. SAE-750174 ; 1975 ; 16p 7refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

## EXHAUST-PORT FUEL INJECTION FOR CHEMICAL REDUCTION OF NITRIC OXIDE

Nitric oxide can be chemically reduced in a vehicle exhaust system if hydrocarbons are supplied to high-temperature exhaust gas near the engine exhaust valves. Ethane was injected into the exhaust ports of engines equipped with either stainless steel or ceramic thermal reactors. Thermal decomposition of the ethane provided hydrogen and hydrocarbon radicals for the gas phase chemical reduction of nitric oxide formed in the engines. Although significant reductions of nitric oxide were



achieved, severe spark retard was required to attain the elevated exhaust temperatures required to effect the nitric oxide reduction. Furthermore, carbon monoxide, hydrogen cyanide, and ammonia were formed, especially with the stainless-steel reactors. In view of these findings, this method for reducing nitric oxide emissions is not felt to be practical for automotive application at the present. Two vehicles were used in the investigation: the first was equipped with a modified 5.471 engine and type 310 stainless steel DuPont V thermal reactors; the second with a modified 7.451 engine and ceramic reactors. The secondary fuel in the study was C.P. grade ethane, which was injected into the engine exhaust ports through the tubes normally used for air injection. The injection rate was determined by a carbon balance technique. The total percent carbon in the vehicle exhaust gas without ethane injection was first determined using emission concentration measurements; then the test was repeated during ethane injection. Reactor outlet temperatures were measured with triple shielded, bare wire, thermocouples; and exhaust gas concentrations were measured with nondispersive infrared analyzers for carbons, and flame-ionization detection analysis for hydrocarbons. Nitric oxides were measured by chemiluminescent analyzers.

by Donald J. Pozniak  
General Motors Corp., Res. Labs.  
Rept. No. SAE-750173 ; 1975 ; 8p 10refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 313

#### **PULSAIR--A METHOD FOR EXHAUST SYSTEM INDUCTION OF SECONDARY AIR FOR EMISSION CONTROL**

The Pulsair concept utilizes inherent exhaust system pressure pulsations to induce secondary air into reciprocating engine exhaust ports for oxidation of unburned hydrocarbons and carbon monoxide. High-speed check valves are actuated by sub-ambient exhaust pressures which arise from reflected exhaust blowdown pressure waves. For multi-cylinder engines, a single check valve set can be used effectively to supply air to an entire exhaust manifold. Experiments with V-8 engines and simple acoustic wave theory have been used to define system fundamentals and design techniques for obtaining high induced airflow rates at specified engine speeds. Procedures are outlined for adapting the concept to L-4, L-6 and V-6 engines. The Pulsair system does not affect net engine power and is potentially less complex than typical air pump systems. Sufficient air can be induced to meet the expected secondary air requirements for many exhaust aftertreatment systems; however, some modifications to conventional exhaust systems may be necessary. Pulsair rates as high as 60% of engine airflow have been demonstrated by modifying the exhaust crossover of a V-8 engine. Optimum exhaust manifolding for Pulsair induction is achieved by connecting 4 or fewer cylinders which fire at equally spaced intervals. These criteria are met with L-4 and V-6 engines, and can be met using 2 manifolds for L-6 engines. By confining the exhaust crossover loop to 1 bank of a V-8 engine, Pulsair rates ranging from 60% of engine airflow at idle to 10% during high speed accelerations have been demonstrated. Maximum airflow is induced when engine speed and pressure pulse rate combine to excite the exhaust system at the resonant frequency. For a given engine-exhaust system, resonant engine speeds are determined by the resonant pres-

sure pulse rate, which can be predicted by a graphical construction technique, and the exhaust system wave length which can be related to a characteristic exhaust dimension by an appropriate acoustic model. Resonant engine speeds are decreased if exhaust manifold volume is increased.

by Richard A. Gast  
General Motors Corp., Res. Labs.  
Rept. No. SAE-750172 ; 1975 ; 16p 10refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 314

#### **EFFECTS OF CELL GEOMETRY ON THERMAL SHOCK RESISTANCE OF CATALYTIC MONOLITHS**

The effects of cell geometry and dimensions on the thermal shock resistance of catalytic monoliths is examined analytically. Two cell geometries, namely square and equilateral triangle, are considered. Thermal gradients predicted by theory compare well with the experimental results. It is found that for equivalent thermal shock resistance the triangular cell requires lower coefficient of thermal expansion than the square cell. Also, as the cell density is increased for higher geometric surface area, both geometries require a reduction in thermal expansion coefficient to preserve their thermal shock resistance. Other considerations affect the overall performance, such as manufacturing advantage and the conversion efficiency. Also, the triangular cell examined has a cell density of 236 square inches with 20% greater geometric surface area than the square cell with a cell density of 200 square inches. If the dimensions of the square cell were adjusted so as to provide the same geometric surface area as the triangular cell, it would also require lower expansion coefficient although not as low as that required by the triangular cell. The laboratory thermal shock test to which the monoliths were subjected proved to be more severe than indicated by the threshold temperature measured by a thermocouple in the hot gas stream. Data from automobile manufacturers indicate that the honeycomb monoliths have more than adequate thermal shock resistance due to their satisfactory expansion characteristics.

by S. T. Gulati  
Corning Glass Works  
Rept. No. SAE-750171 ; 1975 ; 11p 6refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 315

#### **TESTS OF LASER METAL REMOVAL FOR FUTURE FLEXIBLE ROTOR BALANCING IN ENGINES**

Recent developments in the flexible rotor balancing technology area, with emphasis on methods for addition and removal of correction weights is described. The currently existing Multiplane-Multispeed Balancing procedure permits one-step balancing of final shaft-bearing assemblies simultaneously in a number of planes and at a number of speeds. Temporary addition of trial weights to the rotor, and the addition or subtraction of permanent corrections, are presently performed manually in the balancing process. The addition of a computer-controlled laser device to the balancing system shows promise of eliminating direct operator contact with the rotor in the

balancing process, and thus could provide a considerable increase in the precision level at a critical step in the procedure. Preliminary investigations show that design-incorporated provision of suitably-located balancing planes on the rotor, and access to those planes from outside the machine casing through portholes, should permit balancing of machine rotors in place. Check-balancing of rotors without the need for stopping the rotor appears feasible. In summary, it is shown experimentally that a laser can remove quantities of material of the order of 150 milliliters from the edge of a six-inch diameter disc rotating at speeds up to 3000 revolutions per minute in well under two minutes.

by J. M. Tessarik; D. P. Fleming  
Mechanical Technology Inc.; NASA-Lewis Res. Center  
Contract AF-F33614-72-C-1801; NASA-NAS3-14420  
Rept. No. SAE-750170; 1975 ; 11p 10refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 316

### CATALYTIC EMISSION CONTROL SYSTEM FIELD TEST PROGRAM

A field of nearly 250 cars equipped with experimental catalytic converter systems were tested in taxi, police, state and municipal fleets in various cities throughout the United States. A diversified range of customer service, and altitude and climatic conditions was provided. An evaluation of performance and durability in high mileage field service of experimental catalytic emission control systems was made. The fleet comprised groups of cars with hardware and calibration variations designed toward the 1975 Federal and California emission requirements. The converter systems evaluated were primarily a 260 cubic inch underfloor converter and a 140 cubic inch manifold converter. Both bead and monolith substrate catalysts were examined. Test results showed that on the average the systems successfully controlled emissions to below the 1975 Federal and California requirements for greater than 50,000 miles. Engine misfire conditions did cause converter damage in some instances. Systems designed for the low emission requirements of .41/3.4/.40 grams per mile of hydrocarbons/carbon monoxide/nitric oxides exceeded those levels at relatively low mileage due to catalyst deterioration. The 260 cubic inch under floor bead converter exhibited better durability characteristics than the 140 cubic inch manifold converter, but both systems did a good job of controlling emissions on the 1975-76 type systems. Cars tailored for the more stringent 1977 and 1978 emission requirements exhibited considerable losses in fuel economy when compared to 1975 systems. In the field test program, a total of nearly ten million customer miles were accumulated.

by Donald L. Miles; Louis J. Faix; Harry H. Lyon; George W. Niepoth  
General Motors Corp.  
Rept. No. SAE-750179 ; 1975 ; 19p 5refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 317

### HOT CORROSION EVALUATION OF COATED TURBINE MATERIALS

An environmental burner rig test has been developed to support the development and evaluation of oxidation and sulfidation resistant alloys and coating systems. The test facility has been extensively utilized in the development of inherently sulfidation resistant alloys and the evaluation of various alloy/coating systems. Environment burner rig tests have shown that the simple aluminide coatings of C101 provided exceptional resistance to sulfidation attack. The alloy/coating systems are competitive with some of the more expensive overlay coating systems. C101 is a modification specifically developed to provide an improved combination of resistance to cyclic oxidation and hot corrosion and stress rupture strength.

by D. D. Profant; L. J. Fiedler  
Avco Corp., Lycoming Div.  
Rept. No. SAE-750169 ; 1975 ; 8p 2refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 318

### REPORT ON AN INVESTIGATION OF THE HIGH SPEED HAZARDS OF STEEL BELTED PATROL TIRES ON POLICE PATROL CARS. FINAL REPORT

Two police fatalities and one permanent disability have been caused by catastrophic failures of steel belted radial ply tires during high speed police operations. More than 200 other failures were reported by one State highway patrol department. The National Institute of Law Enforcement and Criminal Justice requested the Law Enforcement Standards Laboratory to investigate. No actual tire testing was conducted, but a number of surveys of police agencies, and in particular the California Highway Patrol which has tested several brands of steel belted radial ply tires, were conducted. The patrol recommends that police departments use caution in selecting tires for patrol cars, and that tire manufacturers be required to provide evidence that the tires sold for police use have been tested and certified at speeds of at least 125 miles per hour. Various tire companies have provided some of this information, which is included in the report.

by Jared J. Collard  
National Bureau of Standards, Law Enforcement Standards  
Lab., Washington, D.C. 20234  
Rept. No. NBSIR-75-734 ; 1975 ; 51p  
Sponsored by the National Inst. of Law Enforcement and  
Criminal Justice.  
Availability: NTIS \$4.25

HS-017 319

### NORTH CAROLINA DRIVER RECORD DATA

This dictionary describes the driving population of North Carolina as of December 31, 1974. A 10% sample of all drivers was analyzed with all frequencies being multiplied by 10 to present counts of the proper magnitude for the entire file. The variables recorded by the Division of Motor Vehicles describing the drivers and their driving experience are defined. Violations and accidents, as well as other counts of actions against

an individual's driving record are presented for the last five years, and the total recording period, as all records except those with serious violations or accidents are purged after five years. For each variable value, the meaning, frequency of occurrence and the percent of total population is given. An index is included in the back of the dictionary to aid in locating a described variable within the dictionary.

National Driving Center, Durham, N.C.  
1975 ; 113p

Prepared for the State of North Carolina in cooperation with the North Carolina Div. of Motor Vehicles and the North Carolina Governor's Hwy. Safety Prog.

Availability: Corporate author

HS-017 320

### INORGANIC CHEMICALS TECHNICAL SERVICE AND DEVELOPMENT

Although magnesium is presently in short supply, the future of this metal, especially in the automotive industry, looks promising. The present shortage of magnesium has limited its usage to two potential growth markets, die casting and steel desulfurization. However, the desire of the automotive industry to reduce the weight of cars, and the projected energy requirements to produce magnesium make its future use look very probable. Magnesium's raw material source of supply, sea water, is constant; and the process of electrolytic extraction will be continually improved from an energy and cost standpoint. Bauxite quality, and the fact that most bauxite sources are outside of the United States help to predict that magnesium will become competitive with aluminum on a unit volume basis, in favor of magnesium.

by C. W. Nelson  
Dow Chemical Corp.

Rept. No. SAE-750183 ; 1975 ; 11p 7refs

Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.

Availability: SAE

HS-017 321

### OCCUPANT MOTION IN ROLLOVER COLLISIONS

An analysis of vehicle and occupant motions in rollover accidents is presented. A comparison of the vehicle-occupant interaction in such collisions with the same interaction in fixed-object side impacts is made to demonstrate the actual similarity of these seemingly dissimilar collisions. The vehicle mechanics during rollover is discussed in terms of speed, type of terrain at accident location, vehicle motion, and points of impacts. It is pointed out that, because rollover accidents are upside down, it is not the roof that is crushed, but it is the vehicle body that is crushed down closer to the roof. This factor is crucial in the study of the total collision mechanics. The motion of unrestrained vehicle occupants in rollover and fixed-object side impacts is discussed in terms of the following: the acceleration of gravity pulling occupant downward (or towards the impact point); his original speed and direction of motion; and the force of the interaction of his body with the vehicle interior. The case of an occupant of a falling elevator is considered to emphasize that injury is not necessarily affected by the crush of the vehicle itself. A properly used restraint system allows the occupant involved in a rollover collision to decelerate with the vehicle as it crashes, reduces the chance of ejection, and reduces the chance for occupants to strike one

another. The benefits of restraints under some rollover conditions is shown by analysis of restrained and unrestrained occupants' motion in an identical crash configuration. Illustrations are provided.

by Edward A. Moffatt

General Motors Engineering Staff, Warren, Mich. 48090

n.d.; 20p 4refs

Availability: Corporate author

HS-017 322

### BASIC DESIGN PRINCIPLES OF CHILD AUTO RESTRAINTS

The anatomical and general principles of occupant restraints in automobile collisions are presented with emphasis on the protection of the child occupant. The particular problems presented by the child's underdeveloped skeletal system, and his wide range in size are discussed. Rear facing restraint systems (the most effective), systems employing a load distributing surface in front of a forward facing occupant, and belt harness systems (five point belt for children) are considered. Child restraint design criteria (structural integrity, dynamic interaction with the adult seat, proper use of adult restraints to secure the child's seat, load distribution, limitation of body motions, comfort, useability, and cost) are discussed. The following typical dynamic performance problems in child restraint systems are considered: structural collapse and rupture (bending loads applied to the tubular metal framework of some systems, excessive tensile loading or stress concentrations on molded plastic structures); concentrated loading of the occupant (caused by structural discontinuities or abrupt changes in the stiffness along supporting surfaces); and high occupant accelerations due to harness looseness and/or padding inadequacies.

by J. W. Melvin; R. L. Stalnaker

University of Michigan, Hwy. Safety Res. Inst.

Rept. No. SAE-740936 ; 1974 ; 15p 5refs

Presented at the Automotive Engineering Meeting, Toronto, Canada, 21-25 Oct 1974.

Availability: SAE

HS-017 323

### EVALUATION OF THE FIRST GENERATION UTCS/BPS CONTROL STRATEGY. EXECUTIVE SUMMARY. FINAL REPORT

by J. L. Kay; J. C. Allen; J. M. Bruggeman

JHK and Associates, Suite 1112, 4660 Kenmore Ave., Alexandria, Va. 22304; Peat, Marwick, Mitchell and Co., 1025 Connecticut Ave., N.W., Washington, D.C. 20036

Contract FH-11-8242

Rept. No. FHWA-RD-75-26 ; 1975 ; 28p

Rept. for Feb 1974-Feb 1975. For abstract, see vols 1 and 2,

HS-016 967 and 016 968.

Availability: NTIS

HS-017 324

**AUTOMOBILE COLLISION DATA. AN ASSESSMENT OF NEEDS AND METHODS OF ACQUISITION**

Economics and Science Planning, Inc., 1200 18th St., N.W.,  
Washington, D.C. 20036  
Contract OTA-C11

1975 ; 251p 25refs

Prepared for the Office of Technology Assessment at the request of the House Com. on Appropriations, Transportation Subcom. The results of a study examining the desirability, utility, design and cost of crash recorders and of alternate approaches to gathering collision data (computer crash simulation, controlled laboratory crashes) and methods to improve the accuracy of accident investigation reporting and to increase the utility of national crash data files are presented. Specific federal data collection programs are evaluated. The need for more and better crash data is considered. The characteristics of an adequate data collection program are discussed in terms of: the quantities and rates of adequate data collection; the need for definition, measurement and reporting of causal crash severity; and the importance of an unbiased, relevant, and adequate sampling plan. The following alternatives for an adequate data acquisition program are detailed: doing nothing; updating current programs by adding a mass data acquisition system; providing a mass program at a cost of \$3 to \$10 million yearly; upgrading mass acquisition programs to provide accurate severity reporting at a cost of \$10 to \$20 million yearly; the use of time-history (disc) recorders; the development of a cheap and proliferable causal severity measurement device; or providing a federally-sponsored field trial of uncertain and/or expensive safety aids. Federal responsibility and expenditures for collision data gathering and the legal aspects of crash recorders are discussed, and it is concluded that the federal government alone should support the central data collision activities and that crash recorders provide data admissible in a court of law. Availability: Reference copy only

HS-017 325

**EFFECTIVENESS OF DIFFERENT "APPEALS" IN ROAD SAFETY PROPAGANDA**

The effect of motivating appeals as used in traffic safety propaganda is examined and compared with factual techniques. Subjective assessment and objective measurements of changes in behavior are used. In subjective tests some of the emotional appeals received higher ratings than the factual techniques, but they did not cause any greater change in behavior. The following studies of horror appeal are discussed: a qualitative study of reactions to potentially horrifying material (a subject sample was asked to rate photographs on a 1-7 scale of horror and more explicit photographs were found more horrifying); objective studies of the effect of horror propaganda on seat belt use (seat belt propaganda leaflets of varying degrees of horror were distributed and response, observed in different traffic service areas, was found to be the same regardless of horror content); and an examination of two large scale campaigns on seat belt wearing (the effects of two British television messages, one using a shock appeal, the other a family responsibility appeal, were observed and both approximately doubled seat belt use). Studies of other types of appeal include: reactions to traffic safety commercials (77 subjects were asked to rate each of a sample of 20 commercials and horror, family responsibility, famous person, and factual appeal received the highest rating); the effect on seat belt use of leaflets using three different types of illustration (illustrations included nothing, pleasant highway scene, and badly damaged car and no significant difference was found in

the effectiveness of each); a subjective assessment of the effect on seat belt use of seven different appeals used in traffic safety (a postal survey of 500 drivers and non-drivers rated leaflets with serious appeals as more likely to be effective than non-serious ones); and the effect of leaflets illustrating seven different appeals (a before and after study of the effects of leaflets on seat belt use was conducted at eight traffic service area sites with 1800 observations made for each type of appeal and, although all the leaflets increased belt use, none of the emotional appeals proved more effective than the factual ones). It appears that, of the emotional appeals, the serious ones (horror, responsibility to the family, and famous person) tend to achieve a better result than the non-serious appeals (sex, satire, humor). It is concluded that the most effective appeal would be a basically factual technique with some content of serious emotion, preferably done in a novel way to aid memorability.

by A. M. Mackie; Shelagh D. Valentine  
Transport and Road Res. Lab., Road User Characteristics  
Div., Crowthorne, Berks, England  
Rept. No. TRRL-LR-669 ; 1975 ; 16p 21refs  
Availability: Corporate author

HS-017 326

**FIRST YEAR EFFECTS OF THE ENERGY CRISIS ON TRAFFIC IN KENTUCKY (RURAL HIGHWAYS)**

Traffic volumes, speeds, and accidents for rural Kentucky highways during the period known as the "energy crisis" (December 1973-November 1974) and its after effects were compared to the corresponding period a year earlier. Volume data for each month were obtained from the automatic traffic recording stations located throughout the state and toll road system records. Monthly accident and volume data, and monthly accident rates (accidents per 100 million vehicle miles) were calculated for each highway type (two-lane, three-lane, four-lane undivided, four-lane divided, interstate, parkway). The number of fatalities and injuries for each month was obtained and the monthly severity index was calculated. Traffic speed data were obtained at five locations before and after initiation of the 55-mph speed limit. Safety belt usage among the accident-involved and road surface conditions were determined. Traffic volumes began to decline in December 1973 and, continuing through September 1974. Total travel in the 12 months through November 1974 decreased by 2.3%, and traffic increased by 5% in 1973. It was found that: accident rates during this period decreased by 13.5%; the largest decreases were associated with the highways experiencing the greatest reductions in travel speed; the relationship between traffic speed and accident rate showed a great decrease in accident rate as traffic speeds decreased; and differences between wet-surface and dry-surface accident rates were especially significant, more so for interstate than for two-lane highways. Improved wet pavement skid resistance at the lower speeds obviously contributed to a reduction in accident rates. It is concluded that continuation of the 55 mph speed limit on all rural highways seems advisable.

by Kenneth R. Agent; Donald R. Herd; Rolands L. Rizenbergs  
Kentucky Bureau of Hwys., Div. of Res., 533 South  
Limestone, Lexington, Ky. 40508  
Contract KYP-72-32; HPR-PL-1(10)  
Rept. No. RR-428 ; 1975 ; 51p 5refs  
Availability: Corporate author



HS-017 327

# COPPER--AN AVAILABLE RESOURCE FOR THE FUTURE

Copper and copper-alloys are discussed as highly available resources for the future, in that copper is a very recyclable material. The United States (U.S.) copper and brass industry, which had a record-breaking production year in 1973, is discussed. In that year the industry demonstrated its ability to supply mill products to meet customer needs in a period of high cyclical demand when 7,384 million pounds of copper were consumed. Copper's flow from mine to market and U.S. self sufficiency in copper (95.1% self-sufficient in 1973) are considered. Copper's functional values (electrical properties, corrosion resistance, heat transfer, and aesthetic value), special uses in plumbing, automobile radiators, anti-fouling boat hulls, electric vehicles and solar energy systems are discussed. More usefulness and value is being engineered from each pound of copper. Recycled copper has a higher value (91% of the primary value) than any other recycled metal and it is very conservative of energy (7.85 kilowatt hours per pound of 1.5% ore) compared to the production of other metals.

by W. Stuart Lyman  
Copper Devel. Assoc., Inc.  
Rept. No. SAE-750181 ; 1975 ; 8p 6refs  
Presented at the Automotive Engineering Congress, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 328

# HYDRAULIC CHARACTERISTICS OF TWO BICYCLE-SAFE GRATE INLET DESIGNS. FINAL REPORT

Two design concepts for bicycle-safe grate inlets (the 45°-tilted bar and the so-called "Massachusetts Cascade" design) were tested for hydraulic performance and compared to four other more traditional designs using a modified existing flume 29 feet long and 35 inches wide and recording incoming gutter flow, by-pass flow, and water depths. The parameters of the study were: incoming gutter flow (.008 meter per second to .091 meter per second); longitudinal slope (.005-.130); cross slope (average slope of 1:25); transition area; surface roughness (simulated by enamel paint on a wooden surface); gutter section; and grate (depressed 1 1/2 inches). All grates were tested on five longitudinal slopes (0.005, 0.010, 0.028, 0.054, and 0.075). In most cases, each grate at each slope was tested at six discharges (runs) after a 20 minute waiting period to establish steady flow conditions. The 45° tilted-bar design was tested at the various sizes and bar spacings so that results for several grates using this design concept are reported. The traditional designs used for comparison included one of Oregon's standard longitudinal bar grates (with a bar spacing of 1 3/4 inches) and an Oregon standard transverse bar grate (with a bar spacing of 2 inches). One special vertical-bar design was tested to isolate the effect of tilting the bars. Whenever possible, grates were tested full size, otherwise a 1:1.27 model scale was used. It was shown that the two bicycle-safe grate inlet designs had hydraulic efficiencies comparable to those of Oregon's standard longitudinal bar grate. The longitudinal bar grate is generally considered the most effi-

cient, but these two designs (although further research is needed) seem to offer reasonable bicycle-safe alternatives.

by D. C. Woo; J. Sterling Jones  
Federal Hwy. Administration, Offices of Res. and Devel.  
Rept. No. FHWA-RD-74-77 ; 1974 ; 67p 6refs  
Availability: NTIS

HS-017 329

# A COMPARISON OF THE FACTOR LOADING MATRICES OF TWO DRIVER BEHAVIOR INVESTIGATIONS

Two analyses are reported of driver behavior (in Vienna, Austria and Tübingen, Germany) based on subjective judgements of 40 behavior characteristics of driver subjects made by two observers accompanying the subject in his vehicle and noting the degree to which these characteristics were evident on a nine-point rating scale. In the Vienna study, male subjects (mean age, 36.2) drove over a 40 kilometer route in their Volkswagen "beetles" with one observer in the front and the other behind the driver, in the back. The observed driver behavior variables were grouped into seven factors: careless driving behavior; driving speed; balance of driving style; restrained, tolerant attitude; driving temperament; and decisive, goal-directed driver behavior. In the Tübingen study, 109 male subjects (mean age, 39.5 years) with an average mileage per year per person of 19,000 kilometers drove over a 35 kilometer course. Variables were grouped into the following factors: driving temperament (defensive, not goal-directed); careful driving manner; social component of driver behavior (tolerant attitude); driving temperament and style; behavior in overtaking; decisive, unhesitant driving; unsystematic, ambiguous driving; ensuring safety while driving slowly; and care at junctions. The two studies were compared and the variables, ranked according to loading size, were grouped into the following seven composite behavioral factors: actively careless driving behavior; driving speed; use of clutch; balanced driving style; restrained, tolerant behavior; and lack of driving practice.

by B. Biehl; G. H. Fischer; H. Hacker; D. Klebelsberg; U. Seydel  
Publ: Accident Analysis and Prevention v7 n3 p161-178 (Sep 1975)  
1975 ; 42refs  
Availability: See publication

HS-017 330

# DWI ENFORCEMENT PROGRAMS: WHY ARE THEY NOT MORE EFFECTIVE?

Various misconceptions that have contributed to the lack of effectiveness of the many drunken driving countermeasure programs are discussed. These include the beliefs that: 50% of all traffic deaths involve alcohol; alcohol-related fatal crashes are part of a continuum beginning with the minor fender-bender; one-third of all fatal crashes are caused by problem drinkers; all problem drinkers, heavy drinkers in general, and youth who drink, are high-risk drivers; those arrested for driving while under the influence (DWI) are of the same population as those involved in alcohol-related fatal crashes; and that mass arrests for DWI would reduce the number of alcohol-related fatal crashes. A literature review reveals that: the proportion of all fatal crashes involving alcohol in some causal

way is closer to 30% than to 50%; relatively few alcoholics are high-risk drivers; and it is not alcohol alone that leads to accident involvement but alcohol in combination with such characteristics or conditions as alienation, hostility, aggression, and/or transient traumatic experiences. Mass arrests for DWI have not proven effective in preventing alcohol-related deaths. The frequency of impaired driving is believed to be so great and the relative likelihood of involvement in an alcohol-related fatal crash is so low that current DWI enforcement programs are regarded as inefficient means to prevent alcohol-related deaths. It is concluded that, if fatal crashes are the problem of concern (as opposed to the use of alcohol), the focus of research must be turned from drinking itself to the behavior, characteristics or conditions that precede or accompany fatal crashes, only some of which are encouraged by alcohol. This approach would not only focus attention on the estimated 30% of all fatal crashes that involve alcohol, but on the other 70% as well.

by Richard Zylman

Publ: Accident Analysis and Prevention v7 n3 p179-190 (Sep 1975)

1975 ; 29refs

Availability: See publication

HS-017 331

### ROAD ACCIDENT INVOLVEMENT PER MILES TRAVELED--I

Accident involvement rates are produced and analyzed relative to exposure expressed in miles traveled for a large selection of driver-vehicle variables and their combinations. Questionnaires were sent to about 10% of the 480,000 registered vehicle owners in Queensland, Australia in 1963-64. Results were compared with police records on all significant accidents during 1961. Methods of data collection used in previous studies are discussed. Questions in the Queensland study covered: the data and day of reported trips; address of the garaging of vehicle; type, make, model, and year of manufacture of vehicle; occupation of owner; and for every trip performed, the starting and arriving time, age and sex of driver, origin and destination, mileage, purpose of trip, vehicle occupancy, weight of load, and the type of goods carried. Accident involvement rates are considered in terms of: results already published; risks related to road accidents, involvements in accidents, and injuries; mileage performance data; road accident data; projection of data to a common point in time; reliability of the rates; attributes studied (driver, vehicle, accident, occupant, and injury variables); types of analysis performed; and the method of tabular presentation. The following vehicle use variables are detailed: area of vehicle use and accident involvement (the overall involvement per 100 million miles traveled was found to be 1045 for the whole of Queensland); the within-day variations of involvement rates; and day-of-week variations in involvement rates (Saturdays stand out as worst accident days).

by I. A. Foldvary

Publ: Accident Analysis and Prevention v7 n3 p191-205 (Sep 1975)

1975 ; 16refs

Availability: See publication

HS-017 332

### A SURVEY OF SNOWMOBILING IN VERMONT

Owners of a 10% sample of snowmobiles registered in Chittenden County, Vermont, were sent a questionnaire about snowmobile use patterns during the 1971-72 season, and 85% responded. In addition, driving records were compared for snowmobile owners and non-owners of similar age and sex. Owners were predominately male and under 40. They averaged 460 miles of snowmobile travel per year, much of it at night. Over three-quarters of their machines were made by only four of about 60 manufacturers: Artic Cat, Ski Doo, Moto Ski, and Sno Jet. Half of the owners had 2 or more machines in the family and 41% belonged to snowmobile clubs. There was one loss event (property damage or injury) for every 7000 miles of exposure and one injury event per 16,700 miles. Loss rates per 10,000 miles were 0.79 (Arctic Cat), 0.79 (Ski Doo), 0.69 (Moto Ski), 5.41 (Sno Jet), and 3.33 (all other makes combined). Snowmobile owners, whether with or without mishaps on snowmobiles, did not differ significantly from non-owners with respect to highway crashes or traffic citations in the files of the Department of Motor Vehicles.

by Julian A. Waller

Publ: Accident Analysis and Prevention v7 n3 p207-212 (Sep 1975)

1975 ; 2refs

Availability: See publication

HS-017 333

### THE OUTLOOK FOR ALUMINUM IN AUTOMOBILES

An overview of the future aluminum metal supply situation, the aluminum industry's energy requirements, and the potential for recycling aluminum from scrap autos is presented. Within this framework, pricing, energy conservation and the industry's technological progress in the automotive field are also discussed. Consumption of aluminum, now 81 pounds per car, is predicted to be 200 pounds per car by 1983. It is concluded that: aluminum producers are in an especially strong position with regard to the automotive industry; aluminum ores are virtually inexhaustable; demand for aluminum is strong and growing; prices and profits are at the best levels in 20 years; and the industry should be able to supply all the aluminum needs of the automobile manufacturers if they continue to share their plans and problems with aluminum producers in a meaningful way.

by Jame A. McGowan

Aluminum Co. of America

Rept. No. SAE-750180 ; 1975 ; 8p 2refs

Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.

Availability: SAE

HS-017 334

### THE FIFTY-FIVE MPH LIMIT: EFFECT ON ACCIDENTS

An examination of all technical evidence available on the reduction in traffic accidents with the 55 mph speed limit was made in November and December 1974 to evaluate the speculations regarding this question and the degree of safety attained by lowered speeds on Michigan state highways. The

study was based on: traffic volume; regularly compiled accident and speed survey data for Michigan; and figures on some economic activities in Michigan readily available from outside sources. Speed information was taken from one urban and 25 rural stations. The following economic indicators were examined because of their possible relation to travel volumes and driving habits: gasoline and diesel fuel consumption; average price of gasoline; sales tax receipts; the consumer price index; liquor sales; new car sales by size categories; total labor force; and percent of employment. Freeway accidents and accidents on conventional highways were examined separately. Data analysis was comprised of graphic analysis, comparison of cumulative values for travel and accidents for two time periods (October-April 1973 and 1974), and multiple linear regression studies. It was found that: all types of accidents on all roads in Michigan declined after the fall of 1973; speed trends showed a similar drop long before the speed limit reduction; average and 85th percentile speeds on those roads where speed limits were always below 55 mph also showed a downward trend after the fall of 1973; travel on conventional state trucklines dropped 4.8% during the critical period; freeway travel decline was greater than on conventional roads; general economic activity showed a decline of 1.5% while the automotive sector of the economy declined 18%; factors in freeway and conventional road total accidents showed significant association; and the coefficients for average speed in the derived prediction formulas indicate that each mile-per-hour increase in freeway speed would increase total accidents by 53.2 per month.

by Nejad Enustun; Arthur H. Yang  
 Publ: Traffic Engineering v45 n8 p22-5 (Aug 1975)  
 1975  
 Availability: See publication

HS-017 335

#### FUNCTION OF THE MUSCLES OF THE UPPER LIMB IN CAR DRIVING

The function of the deltoid muscle, the trapezius muscle, and the three main elbow flexors as well as the triceps brachii muscle were tested during driving in a simulator. Electromyographic (EMG) connectors were attached to the subject and the recording equipment and he was asked: to relax the particular muscle completely; perform a moderate or strong contraction of the muscle; and move the steering wheel from the starting position, 90° to the right, back to the starting position, 90° to the left and back to the starting position. The simulated driving included a film sequence of about 380 seconds of driving on a moderately curved straight road and a sequence of about 230 seconds on a very curved country lane. Simulated driving speed was kept fairly constant at 70 km/hr. The EMG activity, picked up by surface electrodes or fine wire electrodes was amplified through an electromyograph or through a universal amplifier and then recorded. It was found that: the anterior and middle portions of the deltoid muscle work during contralateral rotation of the steering wheel, while the posterior portion does not work at all; the deltoid muscle seems to have a purely phasic action in driving; the upper portion of the trapezius muscle works more or less statically with a weak contraction; there is no correlation in the trapezius muscle between the periods of contraction and the angular movements of the steering wheel; the middle and lower portions of the trapezius show much less activity than the upper portion; and the three main elbow flexors (the brachialis, biceps brachii, brachioradialis muscles, and the triceps brachii muscle) show

some activity during driving, but without any meaningful correlation between the periods of activity and the deviation of the steering wheel.

by Solveig Jonsson; Bengt Jonsson  
 Publ: Ergonomics v18 n4 p375-88 (Jul 1975)  
 1975 ; 13refs  
 Includes French and German summary. Supported by the Swedish Work Environment Fund and the Swedish Medical Res. Council.  
 Availability: See publication

HS-017 336

#### HABIT AS THE SOURCE OF AN INAPPROPRIATE RESPONSE

An emergency driving situation requiring a response contrary to the habitual braking response is described, and some important inferences (from such a situation) for safety training are discussed with particular reference to the perceptual style of the individual. Nineteen pairs of male subjects (an accident repeater matched by age, occupation, driving experience and exposure to risk with an accident non-repeater) chosen by questionnaire information from the employees of a light engineering factory took part. Each subject drove on a test track with five other event cars whose movements were switch-activated by the subject's car. Subjects were threatened with electric shock (actually untrue) if they did not successfully avoid a collision due to the sudden movements of the event cars. This method simulates the threat of injury present in a real emergency situation. The only way that the subject could avoid collision was by acceleration of his automobile. Results indicate that: subjects who had experienced repeated accidents in real life were more successful in responding appropriately to the emergency situation than their accident-free counterparts; a number of the non-accident subjects learned the correct response, so that there was little difference in the scores of the two groups on the second emergency; safe driving requires disciplined rule following and, at the same time, resorting to habitual or conditioned responses; and the field-independent (nonconforming) driver is at an advantage in an emergency situation such as the one described. The change in response by some of the non-accident subjects in the second emergency situation presumably results from their learning the appropriate response in the first situation. Whether repetition (more experience) can break down the resistance to an incongruous response remains to be tested. It may be an advantage to the driver to have some skill in perceiving dangers as they develop and so enable him to respond in the proper manner dictated by the circumstances instead of simply following rules.

by Larry Currie  
 Publ: Ergonomics v18 n4 p435-42 (Jul 1975)  
 1975 ; 12refs  
 Includes French and German summary.  
 Availability: See publication

HS-017 337

#### EFFECTIVE UTILIZATION OF PHOTOGRAPHIC AND OPTICAL TECHNOLOGY TO THE PROBLEMS

# OF AUTOMOTIVE SAFETY, EMISSIONS, AND FUEL ECONOMY.

Some of the more important applications of optical technology to automotive safety, emissions control, and fuel economy are examined. The accuracy of a film analysis system and a second-generation lighting and control system for photographing vehicle impact tests are considered. The following highway safety applications of optical techniques are discussed: photographic methods for measuring the spatial distribution of highway luminance; an optical system for measuring on-site accidents; photometric analysis of automotive accident simulations; some optical considerations of direct driver vision; driver's use of indirect visibility systems; automotive forward lighting systems; and real-time information displays for highway use. Biomechanical applications considered are: a high-speed, x-ray, cinematographic system for biomechanical research; the specific measurement of knee motion during a simulated crash; a numerical method of film analysis with differentiation; a laser system for test subject positioning; and a photographic data system for determining the three-dimensional effects of multi-axes impact acceleration on automobile occupants. Specific aspects of automobile safety examined include: eye fixations of drivers in night driving with three headlamp beams; holographic inspection of tires; and an automatic analysis of automobile impact evaluation (solution to the problem of inaccurate film analysis). Also, the whole body (transverse axial) tomographic x-ray scanner, its methods and applications are described. The scientific research of Lord Rayleigh is mentioned.

by Gene G. Mannella, ed; Richard A. Wilson, ed.; Louis W. Roberts, ed.  
Society of Photo-Optical Instrumentation Engineers, 338 Tejon Place, Palos Verdes Estates, Calif. 90274  
Publ: Society of Photo-Optical Instrumentation Engineers, Proceedings, v57, Palos Verdes Estates, Calif., 1975 ; 120p refs  
In cooperation with the National Hwy. Traffic Safety Administration's Hwy. Safety Res. Lab., and the Univ. of Michigan, Inst. of Science and Technology. Includes HS-017 338--HS-017 351.  
Availability: Corporate author

HS-017 338

## FILM ANALYSIS SYSTEM ACCURACY EVALUATION

Techniques are provided for quantifying, in a usable fashion, the error from distortion and resolution limits in optic systems used for high speed film analysis of automobile collisions. The techniques can be used not only to establish the accuracy of a system but also to compare systems. By obtaining such quantitative measurements, a more reliable choice of optical hardware and film can be made for any kinematic analysis requirements.

by D. S. Shaw  
General Motors Safety Res. and Devel. Lab., Milford, Mich.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p2-7  
1975 ; 2refs  
Availability: In HS-017 337

HS-017 339

## A SECOND GENERATION LIGHTING AND CONTROL SYSTEM FOR PHOTOGRAPHING VEHICLE IMPACT TESTS AT THE GENERAL MOTORS PROVING GROUND

A second generation photographic lighting and control system is described as it is used in the high-speed photography of impact testing of a full-scale impact site. A historical review of post system (metal framing system supporting an array of tungsten-iodine quartz floodlights); the photographic pit lighting (twelve fixtures are mounted 40 inches below the road surface on each side of the pit opening and are 16 inches apart); the supplementary lighting (portable units of sealed beam quartz iodine lamps used as "fills," aircraft landing lights used for lighting vehicle interiors); operational characteristics (the photographic console, incident light, circuit protection, voltage, temperature, camera and film used); and the control system (with control electronics and power switching enclosed in separate consoles increasing total camera control capability, power, and timing distributed from the power console to thirteen universal camera stations). Other elements of the system discussed include: camera control (providing an independent power source for each camera outlet and incorporating vehicle speed into the automatic starting of cameras); a vehicle mounted system, interior lighting capacity increased; and a timing system with a light emitting diode and dual channel master timing generator. Some improvements being considered for the system are increased underbody lighting levels and methods to reduce weight and setup time of vehicle-mounted photographic equipment.

by Erik S. Jorgensen; Theodore R. Nielsen  
General Motors Safety Res. and Devel. Lab., Milford, Mich.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p8-15  
1975 ; 4refs  
Availability: In HS-017 337

HS-017 340

## A PHOTOGRAPHIC METHOD FOR THE MEASUREMENT OF THE SPATIAL DISTRIBUTION OF HIGHWAY LUMINANCE

The basic procedures of a photographic method of measuring the low level luminance distribution of highway and obstacle target arrangements are described and, by means of several applications, the possible accuracy and area resolution to be achieved are demonstrated. The quality control considerations are discussed. Calibration frames (for camera-lens-stop setting determination) were obtained by photographing a uniformly illuminated eight gray-level board having luminance values covering the range of the highway scene. Examples of calibration curves are given. The following methods of luminance measurement are discussed: standard manual densitometer; projecting the negatives with a constant current projector and measuring either the illuminance at the projected image portion or the luminance of the reflected image on a good quality screen; and using a computer controlled film scanning systems with a flying spot scanner (FSS). The FSS method was applied to night visibility studies (to determine conditions of optimization of vehicle headlight configurations) and to daytime driving studies (to elucidate such questions as the effect of running lights on the visibility of motor vehicles). The advantages of



the method are shown to be the following: information retrieval speed, whereby a 6x6 grid on the negative can be read several times in a matter of seconds; area scan resolution, whereby that grid corresponds to an angle of less than one minute for the highway scene; and a "light amplification effect," whereby certain areas of poor contrast on the negative can be dramatically amplified on the viewing screen.

by A. A. Ayad; H. F. L. Pinkney; A. C. Walker  
National Res. Council of Canada, Ottawa, Canada K1A 0R6  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p16-25  
1975 ; 6refs  
Availability: In HS-017 337

HS-017 341

### THE CALSPAN SCENE MEASUREMENT SYSTEM-- AN OPTICAL SYSTEM FOR MEASURING ON-SCENE ACCIDENT DATA

A computerized vehicle developed by Calspan to aid in the investigation and reconstruction of automobile accidents is described, including an optical measuring technique to enhance the speed and accuracy with which on-the-scene accident evidence is collected. Evidence reporting, physical evidence report generation, the complete reconstruction program, and the system operation are discussed. The unique feature of this investigative system is the ability to scientifically reconstruct an accident, based on optically gathered evidence. It is concluded that the system should have a positive influence on efforts to improve traffic safety.

by James P. Lynch; Ian S. Jones  
Calspan Corp., Buffalo, N.Y.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p26-9  
1975 ; 4refs  
Availability: In HS-017 337

HS-017 342

### AUTOMOTIVE FORWARD LIGHTING SYSTEMS

The problem of automobile headlamp glare is considered. The results are discussed of two experiments conducted at five different locations throughout the United States measuring the reactions to headlamps of the general motoring public. Drivers appeared to object more often to four low beam lamps on an oncoming vehicle than to confronting two headlamps actually on high beam. This suggests a tendency to object to what seems to be illegal. Another survey conducted at 17 rural, open road locations around the country, has shown that 75% of motorists do not use high beams at all. When driving at 70 mph, this means that such a driver may be 30 mph over the speed at which he can bring his car to a stop in the distance he can see ahead. Various solutions concerning what can be done to improve low-beam deficiency now and headlamps systems for the future (polarized lighting) are offered.

by Roger H. Hemion  
Southwest Res. Inst., San Antonio, Texas  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety,

Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p37-40  
1975  
Availability: In HS-017 337

HS-017 343

### HSRI HIGH-SPEED X-RAY CINEMATOGRAPHIC SYSTEM FOR BIOMECHANICS RESEARCH

The development of a high-speed cineradiographic system applicable to biomechanics and impact trauma research is described. The system allows flexibility in screen viewing size and the possibility of frame rates greater than 1000 per second. Recent developments in high-speed x-ray cineradiography and the background leading to its application to biomechanics research are discussed. The system consists of a four-stage, magnetically focussed phosphor image intensifier optically coupled to a calcium tungstate input screen. Decay time measurements performed on the phosphor are described. The limiting system resolution is determined by the reduction ratio from the phosphor to a 16-mm motion picture film frame. Two other important considerations in the use of the system for biomechanics research are spatial distortion in the image produced by the image intensifier and the use of appropriate targeting techniques in subjects under study. It is concluded that significant advances in targeting techniques must be developed before effective use of high-speed cineradiography can be achieved in wide-ranging biomechanics research.

by Max Bender; W. L. Rogers; John W. Melvin  
University of Michigan, Ann Arbor, Mich.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p42-6  
1975 ; 5refs  
Availability: In HS-017 337

HS-017 344

### KINEMATICS OF KNEE MOTION DURING A SIMULATED CAR CRASH

High-speed flash X-rays of the knee region of a human volunteer were taken during a highly simplified mock car crash (the subject in an armless desk chair on rollers was pushed forward by another person) to determine the best joint modeling technique to be used for anthropomorphic dummies in human knee collision kinematics measurements. The relative positions of a rotating femur about a fixed tibia were observed over a 25° range or rotation. Using an optimization method, an effective pivot location was found that most closely matched the complex motion of the actual knee. This optimum pin position is shown to be nearly 2.5 centimeters from the pin location that would have been obtained by constraining the location to lie along the tibia centerline. Also, the appropriate pin position was located more anteriorly than for tests with non-weight bearing and cadaver subjects.

by S. L. Gordon; M. A. Ringle; B. M. Hillberry; S. A. Shatsky  
National Hwy. Traffic Safety Administration, Biomedical Engineering Group; Purdue Univ., School of Mechanical Engineering; Armed Forces Radiobiology Res. Inst.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety,

HS-017 345

Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p47-52  
1975 ; 12refs  
Availability: In HS-017 337

HS-017 345

**A NUMERICAL METHOD OF FILM ANALYSIS  
WITH DIFFERENTIATION WITH APPLICATIONS IN  
BIOMECHANICS**

A numerical method of curve fitting with provisions for subsequent differentiations used to provide a basis for the analysis of high-speed films of human volunteers on a decelerator is described. The method of harmonic analysis (the Fourier series), providing a simple, straight forward technique for curve fitting in a least squares sense, is briefly discussed. A series of sled tests using anthropomorphic dummies and human volunteers conducted in 1960 are described. A rationale for estimating the magnitude of discrepancy which can exist between actual and computed body accelerations is presented. Given information on sampling rate, pulse duration, standard error of measurement, and limits on rate change of acceleration, this estimation method provides a bound on expected error in computer acceleration as a function of cutoff frequency. The best cutoff frequency was found to be somewhat higher than that actually used, although the difference in estimated error appeared small.

by Roger C. Haut; E. Paul Remmers; W. Weston Meyer  
General Motors Res. Labs.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p53-61  
1975 ; 5refs  
Availability: In HS-017 337

HS-017 346

**A LASER SYSTEM FOR TEST SUBJECT  
POSITIONING IN AUTOMOTIVE SAFETY  
RESEARCH**

A laser system is described which facilitates the alignment of a sagittal plane of the subject and the positioning of target points on the subject to specific sagittal plane coordinates relative to the impact sled used in crash simulation testing. The background development of this system (filling the need for test subject positioning in impact sled experimentation) is discussed. The structure and layout of the lateral and overhead laser systems of helium-neon continuous wave lasers are illustrated. Methods are explained for facilitating accuracy in positioning the laser at the proper coordinates at the surface plate, in aligning the laser beam perpendicular to the plane of the laser cradle magnetic bases, and in surface flatness. Also, methods are described for providing precision in locating coordinates on the surface plate, locating the laser reference beam at the coordinates, and positioning the test subject target point on the axis of the laser beam. System adjustment capabilities of the lateral and the overhead laser systems are considered. The various adjustment tasks of the final alignment of the laser positioning system are discussed. It is concluded that: a laser alignment system with accuracy and precision, adequate for test subject positioning applications in sled testing, is attainable using readily available commercial components and machining tolerances routinely achieved by the typical shop;

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and the laser system alignment procedure is straightforward and the alignment is easily checked.

by Gerald W. Nyquist; Harold J. Mertz  
General Motors Res. Labs.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p62-8  
1975 ; 2refs  
Availability: In HS-017 337

HS-017 347

**A PHOTOGRAPHIC DATA SYSTEM FOR  
DETERMINATION OF THREE DIMENSIONAL  
EFFECTS OF MULTIAXES IMPACT  
ACCELERATION ON LIVING HUMANS**

A photographic data system for determination of the three-dimensional effects of multiaxes impact acceleration on human subjects is described in both its hard and software phases. Accounts of filming and lighting schemes for "G" environments, digitization of photographic data, and a mathematical solution for the position and orientation of a multiply-targeted rigid body as acquired by a number of fixed cameras are included. A simple analysis relating the position of a point in three-dimensional coordinates to its image in a filmplane, is developed. The approach used for bench testing cameras to calculate lens parameters is described. Illustrations or diagrams are provided of the following: the laboratory accelerator, the photo-data acquisition console, the subject born instrumentation, the instrumented volunteer, the kinematic parameters, the lens-filmplane system, and the camera calibration setup.

by Edward B. Becker  
Naval Aerospace Medical Res. Lab. Detachment, New Orleans, La.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975 p69-78  
1975 ; 6refs  
Availability: In HS-017 337

HS-017 348

**EYE FIXATIONS OF DRIVERS IN NIGHT DRIVING  
WITH THREE HEADLAMP BEAMS**

Two subjects, age 25 and 40, drove an automobile over a 15-mile two-lane course in the daytime and at night using an American and a European low beam headlamp and a third mid beam headlamp. The eye fixations of the drivers were measured, using a head-mounted, silicon diode television camera, and light reflection from the cornea as the recording device. Factors considered are: the mean duration of eye fixation; the distribution of the percent duration of glances on straight road sections; the distribution of eye fixations at opposing traffic; the effects of road geometry and headlamp beams on lateral distribution of eye fixations; the effects of road geometry and headlamp beams on preview distance; and road delineation. Comparisons between daytime and night eye fixations suggested that dwell time was longer when looking straight ahead at night than in the day, and there was a reduction in the proportion of the viewing time devoted to the left lane at night than in the day, when there was no oncoming vehicle. Drivers

looked at approaching vehicles in both day and night conditions with glance durations of intermediate length (0.70 - 1.07 seconds), which increased in frequency as the separation distance between the vehicles decreased. At night, preview distances were less than in the day. Other findings include: a characteristic shift of eye fixations in the road direction in both day and night driving; eye fixations were influenced by the beam pattern characteristics at night; on left curves the American and European low beams provided eye fixations most closely resembling those used in daylight; and on straight sections and particularly right curves, the mid beam provided the most compatible distribution of glances. A revised composite mid beam incorporating characteristics of the European low beam is suggested as an improved meeting beam.

by Rudolf G. Mortimer; Craig M. Jorgeson  
University of Michigan, Hwy. Safety Res. Inst., Ann Arbor, Mich.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p81-8  
1975 ; 8refs  
Availability: In HS-017 337

HS-017 349

# HOLOGRAPHIC INSPECTION OF TIRES

A method of non-destructively detecting internal anomalies or void areas in tires using holographic interferometry and vacuum stressing is described. A total of 2,241 new automobile tires scheduled to be run on road endurance and treadwear tests were inspected by the holographic method. In almost every case where an anomaly was indicated by holography, some type of tire irregularity was found. The distribution of anomaly sizes in an 816 tire subsample is indicated. The holographic process itself is explained and diagrammed along with the reconstruction process. Also, examples of reconstructed and unreconstructed holograms are provided. Some correlation between original anomalies of 1 1/2 inches or larger and subsequent location of structural damage was noted under accelerated maximum load test conditions. In two cases, the damage was responsible for premature removal. From these results it is estimated that the frequency of tires from the total population inspected that would experience premature removal attributable to an original anomaly on these accelerated tests is about 0.1%.

by Michael J. Cannazzaro; Frederick W. Hill  
General Motors Corp., Proving Ground Sec.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975 p89-93  
1975 ; 3refs  
Availability: In HS-017 337

HS-017 350

# ACTA (AUTOMATIC COMPUTERIZED TRANSVERSE AXIAL)--THE WHOLE BODY TOMOGRAPHIC X-RAY SCANNER

The automatic computerized transverse axial (ACTA) tomographic scanner, designed for the radiological delineation of tissue abnormalities through the whole body is described. The scanner accurately portrays in pictorial and quantitative form

both the nature of the lesion and its precise three-dimensional location in the body. The concept of ACTA tomography involves the production of X-ray absorption profiles made at different angles in the same cross-sectional plane. The profiles are samples, digitized, and fed into a computer which synthesizes them into a picture giving the relative absorption coefficients of the body cross section in the plane of the scan. The picture is reconstructed immediately upon completion of the X-ray beam scan and is displayed on a color television console and two black-and-white consoles. The color television display shows at a glance the areas of different ranges of absorption coefficients as areas of different colors which, in turn, will facilitate the clinical diagnosis. The picture can also be stored for permanent record.

by R. S. Ledley; J. B. Wilson; H. K. Huang  
National Biomedical Res. Foundation, Georgetown Univ. Medical Center, 3900 Reservoir Rd., N.W., Washington, D.C. 20007  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p94-107  
1975 ; 6refs  
Availability: In HS-017 337

HS-017 351

# AUTOMATIC ANALYSIS OF AUTOMOBILE IMPACT EVALUATION

A method is described for solving the problems of inaccurate and inefficient film analysis by using an optical sensor capable of digitizing information and transferring the information at a high throughput rate to a computer for real-time processing. An automatic programmable film reader with the following integral parts is discussed: a digitizing sensor (sensor tube, sensor optics, sensor electronics); a display monitor with scan converter; a film analyzer; a digital control interface; and a central processor unit (keyboard printer, magnetic tape unit, paper tape reader). The software is considered in detail. The modes of operation (manual, single frame automatic, completely automatic, error detection, software documentation) are discussed and the complete operational algorithm is diagrammed.

by D. Richard Aten  
DBA Systems, Inc.  
Publ: HS-017 337, Effective Utilization of Photographic and Optical Technology to the Problems of Automotive Safety, Emissions, and Fuel Economy, Palos Verdes Estates, Calif., 1975, p108-15  
1975  
Availability: In HS-017 337

HS-017 352

# HIGHWAY DESIGN FOR MOTOR VEHICLES--A HISTORICAL REVIEW [INTRODUCTION AND PART 1, THE BEGINNINGS OF TRAFFIC MEASUREMENT]

Early developments in highway design, problems encountered, and examples of federal aid are briefly discussed. One of the main obstacles facing the states and federal government was a scarcity of basic information on how highways should be developed to adapt motor vehicle traffic to economic and social needs, and how they should be constructed to stand up under ever-increasing traffic loads. Research backed by the

Bureau of Public Roads (BPR), established in 1916, led to the first highway magazines. The first national program for highway research was formulated by the National Research Council (NRC) and the research received strong stimulus from the Hayden-Cortwright Act of 1934 and subsequent federal-aid acts which authorized the states to spend up to 1 1/2% of their federal-aid funds first for planning and engineering investigations and for highway research. The history of the traffic census and the method of designating traffic units (collars, tons) are considered. The methodology of early American traffic censuses (Maryland, Alabama, Los Angeles, California) is discussed. These traffic censuses served to chronicle the decline of animal-drawn vehicles as components of highway traffic. The investigation of the California highway system in 1920 by BPR, the first cooperative research effort between a state highway department and the federal government, is discussed. In addition, the second Connecticut Highway Transportation Survey, the first to be primarily research-oriented, to make extensive use of the origin-destination interview, and to employ machine tabulation to analyze the data, is analyzed and the development of ADT (average annual daily traffic) as the unit of traffic is outlined.

by Frederick W. Cron

Publ: Public Roads v38 n3 p85-95 (Dec 1974)

1974 ; 18refs

See also HS-017 353, (part 3), and HS-017 354, (part 4).

Availability: See publication

HS-017 353

#### **HIGHWAY DESIGN FOR MOTOR VEHICLES--A HISTORICAL REVIEW. PART 2. THE BEGINNINGS OF TRAFFIC RESEARCH**

Early efforts in traffic research are discussed. The Maine Highway Transportation Survey of 1924 is explained as it was used for road classification and the estimation of future traffic. More refined and reliable than previous efforts, this survey influenced later studies and highway administration. The U.S. Bureau of Public Roads (BPR) cooperated with Cook County, Illinois in an investigation of county highway traffic and the formulation of a plan of improvement in 1924. Also, a 1925 Ohio traffic survey and a Vermont highway transportation study conducted in 1926 are mentioned. The first metropolitan regional traffic study, conducted in Cleveland, Ohio in 1927, is discussed in some detail. The study included the most extensive origin-destination survey made up to that time, special studies of population density, distribution and trend of population, and industrial growth in the city and suburban area, and time and lateral placement studies to estimate the traffic capacity of streets of various widths. It resulted in an elaborate plan for improvements. Gasoline consumption was found a more reliable index of traffic growth than motor vehicle registration in the Western States Traffic Survey. The New Hampshire Traffic Survey of 1931 gave traffic students an opportunity to check forecasts made five years earlier from population and vehicle registration estimates. The Michigan Highway Transportation Survey of 1930-31 was the first to study the traffic on all public roads of a state simultaneously. The Connecticut survey of 1934-5 provided the first statement of the level of service concept of highway capacity. The first driver behavior study consisting of 675,000 vehicle speed observations made in 1934 in Rhode Island is discussed. Traffic counting methods and concepts (key stations, blanket stations, special stations, key station schedules, the 40-hour schedule, and the statistical day) and the development of automatic traf-

fic counters by BPR (photoelectric cells, road switches, automatic recording printers) are detailed. The progress of hourly traffic variations studies and their effect on highway design determination are discussed. The development of toll-road and interregional highway planning (1937-1944) is examined up to the point of the final approval of the National System of Interstate Highways, totaling 40,000 miles.

by Frederick W. Cron

Publ: Public Roads v38 n4 p163-74 (Mar 1975)

1975 ; 21refs

See also HS-017 352 (Introduction and Part 1), and HS-017 354 (Part 3).

Availability: See publication

HS-017 354

#### **HIGHWAY DESIGN FOR MOTOR VEHICLES--A HISTORICAL REVIEW. PART 3. THE INTERACTION OF THE DRIVER, THE VEHICLE, AND THE HIGHWAY**

The regulations and standards concerning road width are traced up to 1920 when most states used a paved width of 18 feet with five foot shoulders as a standard. Studies of the lateral distribution of traffic on the road surface made at a time when painted centerlines were novelties are discussed. Motion picture placement studies concluded that pavements of a 22-foot width are best for mixed traffic. Road speed studies conducted in California (1921-22), Maryland (1933), Michigan (1933), and Washington are reported. Their methods were cumbersome or imprecise or they measured only spot speeds. The progress of overtaking maneuver research and knowledge is considered. Types of passings (flying passes, accelerative passes) and the time required for completion of the maneuvers were determined. The differences in individual performance in overtaking were realized and considered. During 1939 and 1940 the Bureau of Public Roads (BPR) and state highway departments used an improved system of road switch detectors for studies of overtaking in Massachusetts, Illinois, Texas, California, and Oregon (total of 21,000 maneuvers observed). Speed, distance, and traffic density measurements were made and a table of safe distances for the overtaking maneuvers was formulated. The improved equipment developed by BPR in the 1930's (the speedometer and placement detector, the portable traffic recorder) is discussed along with design policies resulting from the use of it. Studies concerning the effects of bridge width, bridge curbs and parapets on driver behavior, leading to minimum bridge width standards, are considered, and measurements made of improvements in trip time at a newly constructed New Jersey high-level viaduct are discussed. From all of these studies of driver behavior, a sufficient data base was achieved for the vehicle carrying capacity of roads to be determined.

by Frederick W. Cron

Publ: Public Roads v39 n2 p68-80 (Sep 1975)

1975 ; 33refs

See also, HS-017 352 (Introduction and Part 1), and HS-017 353, (Part 2).

Availability: See publication



HS-017 355

### THE EFFECTS OF THE ENERGY CRISIS AND FIFTY-FIVE MPH SPEED LIMIT IN MICHIGAN

The finding of a multivariate analysis of Michigan traffic accident, volume, and violations data for the periods before, during, and after the peak energy crisis months of 1974 are presented. A computer algorithm is used to seek out factors explaining the differences in fatal accidents within the compared periods. This algorithm guide is used to make similar comparisons for the same time period of records of all reported traffic accidents and of highway travel and driver exposure. Daylight savings and 55 mph speed limit effects and pedestrian fatality changes are discussed. The most significant feature of the energy crisis and the 55 mph speed limit is found to be the response of drivers according to age group and the resulting reduction in traffic fatalities by age group (drivers age 20-24 and 35-64 showed a 42.8% reduction in fatal accident involvement). The drop in fatalities on non-limited-access United States (U.S.) and other state highways was 45.9%. It is concluded that: the 7% reduction in driver exposure due to the energy crisis does not alone account for the 29% reduction in fatal accidents during the first half of 1974; the 1974 speed reduction on all road categories (-10 mph on Interstates, -5 mph on other U.S. and state trucklines, and -3 mph on county and local roads) reduced crash severity resulting in fewer fatalities; and the 55 mph speed limit is effective in fatality reduction when enforced. The 41% reduction in fatal involvements on non-Interstate highways, during the peak of the energy crisis, even with only a 5 mph decrease in average speeds suggests that speed limits even lower than 55 mph on these roads, if strictly enforced, would lead to lower fatality rates. Other factors found to result in slower collision speeds and less frequent collisions include less night driving, less weekend driving, less driving by males, more uniform speed distributions, and closer adherence to mean speeds. It is suggested that the 50% fatality rate increase in the last half of 1974 for drivers aged 17-19 and their disproportionate share of speeding violations during the energy crisis shows a need for improving driver behavior within this age group by such direct active measures as warning letters, driver improvement sessions, court admonitions, or special reviews and examinations at license renewal time.

by James O'Day; Daniel J. Minahan; Dan H. Golomb  
 Publ: HIT Lab Reports v5 n11 p1-15 (Jul 1975)  
 1975 ; 18p refs  
 Availability: See publication

HS-017 356

### COMPUTER SIMULATION OF VEHICLE-TO-BARRIER IMPACT--A USER'S GUIDE

A description of the mathematical model and instructions for operating the General Motors Research Laboratories' Front-End Barrier Impact Simulation (FEBIS) program are provided. In addition, static testing of the structural components on which the impact simulation program relies for input data is described. The program is capable of analytically predicting dynamic vehicle response to a straight head-on impact against a vertical, rigid, and fixed barrier. The simulation model, developed primarily for a passenger car with a front engine, rear-wheel drive, and a separate frame construction, is shown schematically. A crush test machine, a slow speed horizontal press, was used to load and plastically deform the following vehicle components: the torque box (from the engine cross

member back into the side rails); the front frame (all frame structure and bumper forward of the spring pocket-engine crossmember); the driveline (force-displacement characteristics obtained from rearward pushing on the driveshaft); the sheet-metal (the assembly of sheet metal, radiator, grills, and other attached parts above the frame and forward of the body); the firewall; the radiator; and the engine and transmission mounts. The operation of the program is described in terms of: program organization; input variables; and the editing of the input data. Static force displacement curves are given for all aspects of the crush testing and photographs of the test setups are provided. A source list of the simulation program, as well as flow charts, and sample printed and graphic output, are included.

by Kuang-Huei Lin; James A. Augustitus; Mounir M. Kamal  
 General Motors Res. Lab., Engineering Mechanics Dept.,  
 Warren, Mich. 48090  
 Rept. No. GMR-1943 ; 1975 ; 113p  
 Availability: Corporate author

HS-017 357

### POSITION AND MOBILITY OF SKELETAL LANDMARKS OF THE 50TH PERCENTILE MALE IN AN AUTOMOTIVE SEATING POSTURE. FINAL REPORT

Anthropometric test devices were used to define: the position in space of a human occupant (50th percentile male) of a car seat; spatial relations between the various parts of the body; and the relationships between project findings and automotive design tools such as the H-point machine and the "golden shells." The literature of anthropometry, ergonomics, posture, biomechanics, anatomy, Society of Automotive Engineers (SAE) activity, dummy development, and rulemaking activity were reviewed to establish the state of the art and develop plans for future work. The following were determined: anthropometric landmarks and reference frames; the shape of the thoracic skeleton; seated position of 50th percentile male (using anthropometric techniques, using X-ray techniques, and considering anthropometric error); hip pivot point versus a 3-D H-point machine; relative body segment trajectories; dummy master body forms; and seated geometry for other human percentiles.

by D. H. Robbins; H. M. Reynolds  
 University of Michigan, Hwy. Safety Res. Inst., Huron Pkwy.  
 and Baxter Rd., Ann Arbor, Mich. 48105  
 Rept. No. UM-HSRI-BI-74-4; VRI-7.1 ; 1975 ; 75p refs  
 Rept. for 15 Oct 1973-30 May 1974. Sponsored by the Society of Automotive Engineers, Vehicle Res. Inst.  
 Availability: SAE

HS-017 358

### THE EFFECT OF SENSORY RESTRICTION UPON PERCEPTION OF DRIVING SPEEDS AT THIRTY MILES PER HOUR AND BELOW

The results of a study investigating the perception of speeds from 5-30 mph and examining the role played by vision and audition in this perception are reported. Twelve university students (6 males and 6 females with mean age of 22 years and driving experience of 5 years) served as subjects by being passengers in a car (1967 Rambler American) under the conditions of normal, no sight (blindfolds), restricted hearing (industrial ear plugs and muffs), and no sight plus restricted hearing.

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Under each condition, the subject made speed estimates at 5, 10, 15, 20, 25, and 30 mph (in random order). Tests were conducted on a parking lot 200 yards long by 20 yards wide. The results were analyzed using both algebraic and absolute error values which were expressed in terms of mph deviations as well as in terms of percentage inaccuracy. The no-sight condition was found to produce more error when algebraic values were used, these errors being overestimates of actual speeds. Higher speeds produced greater error when mph inaccuracy (both algebraic and absolute) was the measure and at lower speeds more inaccuracy in speed estimation was found in terms of percentage values of absolute error. The restriction of hearing alone or in addition to blindfolding of the subject did not result in greater inaccuracy of speed estimation. These results are discussed in light of the findings of earlier studies.

by Laura MacFeeters; Gerald J. S. Wilde  
Queen's Univ., Kingston, Ontario, K7L 3N6, Canada  
1975 ; 69p 13refs  
Includes French resume.  
Availability: Corporate author

HS-017 359

#### ALCOHOL IN THE BLOOD OF NEW ZEALAND DRIVERS.

An attempt is made to describe trends in blood sampling of New Zealand drivers suspected of being under the influence of alcohol since the introduction of blood test legislation in May 1969 and the aspects of the analysis and analytical accuracy achieved in the study of the alcohol content of blood are considered. General considerations include: the problem of the New Zealand drinking driver; alcohol and fatal road accidents; and age/alcohol level/time period studies of intoxicated drivers. The following techniques of blood alcohol analysis are discussed: gas chromatography; diffusion analysis; a rapid method for headspace analysis of blood alcohol; storage of blood alcohol samples; and breath alcohol tube studies.

by I. R. C. McDonald; J. P. M. Bailey; K. W. Dalzell; K. J. Duke; P. S. Groom; D. J. Hogan; J. F. Lewin; A. W. Missen; H. S. Roberts; G. R. Scott; H. M. Stone  
New Zealand Dept. of Scientific and Industrial Res., Science Information Div., P.O. Box 9741, Wellington, New Zealand.  
Rept. No. Information-Ser-101 ; 1974 ; 81p 25refs  
Includes HS-017 360--HS-017 368.  
Availability: Corporate author

HS-017 360

#### THE PROBLEM OF THE NEW ZEALAND DRINKING DRIVER

The development of legislation to deal with the drinking driver is traced, and the present procedure for administration of the breath and blood sampling is described. The statistics of drinking and driving, blood sampling, alcohol analysis, variation in sampling rates, and evaluation of the screening breath test are discussed. Detailed figures on the following are presented: the annual sampling rate in urban areas of New Zealand; sampling percentages in various blood alcohol ranges; mean delays in

sample analysis; and percentage of samples according to time of day.

by I. R. C. McDonald  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.  
Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood of New Zealand Drivers, Wellington, New Zealand, 1974 p10-24  
1974  
Availability: In HS-017 359

HS-017 361

#### ALCOHOL AND FATAL ROAD ACCIDENTS

A detailed examination of alcohol involvement in fatal accidents, based on automobile accident records for 80% of the fatal crashes in New Zealand in 1970, is reported. Considerable emphasis is placed on the time and day of the week of the accident, and on the age of the driver, particularly for those at fault in the accident. It was found that: 31%-61% of the accidents involved alcohol; on Friday and Saturday nights (accounting for 28% of all fatal accidents) 63%-94% of all fatal accidents involved alcohol; on the weekdays only 6% involved alcohol; 58% of the drivers involved in fatal accidents and who had taken alcohol were under 26, whereas only 30% of drivers at fault in fatal accidents and who had not taken alcohol were under 26; and the New Zealand breath test procedure does not detect as high a proportion of young drivers as are involved in fatal accidents in which alcohol is a factor. It was also found that: only a very small proportion of women drivers are involved in fatal accidents where alcohol is a factor; and drivers in fatal accidents have apparently the same blood alcohol distribution as drivers giving blood samples after breath tests.

by J. P. M. Bailey  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.  
Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood of New Zealand Drivers, Wellington, New Zealand, 1974 p25-32  
1974  
Availability: In HS-017 359

HS-017 362

#### AGE--ALCOHOL LEVEL--TIME PERIOD STUDIES OF INTOXICATED DRIVERS

Detailed information regarding the age, alcohol level, and time of sampling of all drivers breath-tested since May 1, 1969 in the Otago-Southland area of New Zealand is analyzed. The main findings were: the dominance of the younger driver when the number of samples taken is considered; drunk driving offences in New Zealand are almost exclusively restricted to male drivers; already more than 1.5% of the male drivers in one age group (20-year old) are being sampled per annum; the relatively low alcohol levels of younger drivers and high alcohol levels of older drivers; the incidence of very high blood alcohol levels is almost exclusively the problem of older drivers; over half of all samples are taken on Friday or Satur-

February 29, 1976

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day night; and nearly three-quarters of all samples are taken over the weekend.

by G. R. Scott; J. P. M. Bailey  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.  
Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood  
of New Zealand Drivers, Wellington, New Zealand, 1974 p33-  
38  
1974  
Availability: In HS-017 359

HS-017 363

#### **DETERMINATION OF ETHANOL IN BODY FLUIDS BY GAS CHROMATOGRAPHY**

Details of the gas chromatographic method of blood alcohol analysis (using an n-propanol internal standard) and a correction method, developed to allow for analytical tolerance are described. Standard ethanol solutions are prepared from a stock ethanol shown by gas chromatographic analysis and density determinations to have an ethanol content of not less than 99.76%. The gas chromatograph is calibrated by determination of the n-propanol dilutions of a 200 milligram per 100 milliliter aqueous ethanol standard, carried out under identical conditions as for blood dilution. The correction procedure was developed from a number of surveys and uses a formula for deriving a 99.9% confidence figure for reporting the ethanol level.

by H. M. Stone  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.  
Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood  
of New Zealand Drivers, Wellington, New Zealand, 1974 p39-  
41  
1974  
Availability: In HS-017 359

HS-017 364

#### **ASSESSMENT OF THE ACCURACY OF THE GAS CHROMATOGRAPHIC METHOD OF ALCOHOL ANALYSIS OF BLOOD**

An intensive study of the techniques for the gas chromatographic determination of alcohol in blood is described, and, through collaborative analysis surveys, a mathematical analysis of precision and accuracy is made. To locate the sources of variations in blood alcohol values found in replicate analyses of a given blood sample the following surveys were conducted measuring: variations within laboratories; variations within and between laboratories with and without replications; variations with two analysts only, from two laboratories; and variations from three analysts in one laboratory. It was found and concluded that: variations in mean levels of blood alcohol contents of up to 5 milligrams per 100 milliliters (5 units) between different laboratories can be partly accounted for by differing techniques in making up dilutions at different laboratories; replicate readings show a standard unit of about 4 units; assuming normality at the tails of the distribution, a 99.9% one-sided confidence interval would amount to about 12 units (92% to 6 units); and on a survey carried out at one laboratory over one day, the standard error was less than 2 units, giving a

99.9% one-sided confidence interval of less than 6 units, again assuming normality at the tails.

by H. S. Roberts; H. M. Stone  
New Zealand Dept. of Scientific and Industrial Res.  
Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood  
of New Zealand Drivers, Wellington, New Zealand, 1974 p42-  
55  
1974  
Availability: In HS-017 359

HS-017 365

#### **DIFFUSION ANALYSIS [OF BLOOD ALCOHOL]**

The errors and limitations of the diffusion principle for the analysis of blood alcohol are considered. The apparatus, reagents, and method of diffusion analysis are described. Common measurement errors for the technique are assessed. Results of correlations with prepared beef blood alcohol standards, and with the gas chromatographic method show clearly that the diffusion method is an accurate procedure for determining blood alcohol concentrations.

by D. J. Hogan; K. J. Duke; K. W. Dalzell  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.  
Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood  
of New Zealand Drivers, Wellington, New Zealand, 1974 p56-  
62  
1974  
Availability: In HS-017 359

HS-017 366

#### **A RAPID METHOD FOR THE HEADSPACE ANALYSIS OF ALCOHOL IN BLOOD**

A method (F40) of gas chromatographic analysis of blood alcohol is described based on direct sampling of the headspace above heated blood samples. The materials and method are detailed. To test the accuracy of the F40 method, 120 blood samples were analyzed by the F40 and by a routine chromatography method. It was found that 91.7% of the F40 results differed by 10 milligrams per 100 milliliters or less from the routine analysis value. Also, a survey analysis of blood alcohol levels using the F40 and three other methods yielded comparable results for each method. Evaluations of the F40 method of blood alcohol analysis, capable of processing up to 60 samples per working day, are ongoing.

by A. W. Missen  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.  
Publ: HS-017 359 (Information-Ser-101), Alcohol in Blood of  
New Zealand Drivers, Wellington, New Zealand, 1974 p62-6  
1974  
Availability: In HS-017 359

HS-017 367

#### **STORAGE OF BLOOD ALCOHOL SAMPLES**

The effect of variations in the sodium fluoride content, and of storage time on the alcohol content of blood samples is studied. Four different sets of analytical results comparing variations by storage time and number of openings of the blood alcohol bottle are examined. In unopened samples, preserved

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with 1% of sodium fluoride and stored up to 6 months under refrigeration, changes in alcohol content do not generally exceed 20 milligrams per 100 milliliters. With repeated openings of the same bottle, the principle effect is ethanol loss.

by H. M. Stone; P. S. Groom  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.

Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood  
of New Zealand Drivers, Wellington, New Zealand, 1974 p67-  
71

1974  
Availability: In HS-017 359

HS-017 368

### BREATH ALCOHOL TUBE STUDIES

The calibration and limitations of breath alcohol tubes are assessed. An apparatus used to produce ethanol/air mixtures of known ethanol concentration for calibration of the breath-test tube is illustrated. Possible sources of error in practice for the Drager Alcotest R80 tube (tube reading, bag inflation time, tube defects, bag failure) are discussed. The failure rate of the R80 tube in the hands of experienced enforcement officers is shown to be much lower than expected. It is proposed that a further breath test be introduced, calibrated to read positive at about 170 milligrams per 100 milliliters of blood, but to be interpreted as unequivocal evidence that the blood alcohol level is in excess of 100 milligrams per 100 milliliters.

by H. M. Stone; J. F. Lewin  
New Zealand Dept. of Scientific and Industrial Res.,  
Chemistry Div.

Publ: HS-017 359 (Information-Ser-101), Alcohol in the Blood  
of New Zealand Drivers, Wellington, New Zealand, 1974 p72-9  
1974

Availability: In HS-017 359

HS-017 369

### A METHODOLOGY FOR DETERMINATION OF GRADE CROSSING RESOURCE-ALLOCATION GUIDELINES. FINAL REPORT

A computer-aided analytical approach is described for estimating the potential benefits, costs, and implementation implications associated with the allocation of grade crossing safety resources. Three types of information are required as input: the grade crossing population, categorized by hazard, location (urban/rural), and existing warning systems; warning system alternatives, characterized by cost and effectiveness; and criteria for acceptable or preferred resource-allocation strategies (required benefit-cost ratio, total resources available, number of fatalities to be prevented). A computer program has been prepared that determines all solutions meeting stated criteria and characterizes them in detail (specifying warning systems for passive, flashing light, and automatic gate urban and rural crossings). The operation is highly interactive, and requires only seconds of computer time. Examples are presented based upon national statistics, and cases are chosen to indicate sensitivity to uncertainties in input data. An extensive discussion of the currently-estimated crossing population is included, with a brief review of accident prediction equations. It is concluded that the methodology utilized provides a convenient and flexible means of analysis. Detailed, quantitative information is readily obtained based upon alternative as-

HSL 76-02

sumptions, criteria, and input data. The implications of various policy options can thus be readily determined.

by John B. Hopkins; Morrin E. Hazel  
Department of Transportation, Transportation Systems Center,  
Kendall Square, Cambridge, Mass. 02142  
Rept. No. DOT-TSC-FRA-75-15; FRA-ORandD-76-04 ; 1975 ;  
66p 13refs  
Rept. for Jun 1973-May 1975.  
Availability: NTIS

HS-017 370

### EVALUATION OF EFFECTIVENESS OF PUBLIC EDUCATION AND INFORMATION PROGRAMMES [PROGRAMS] RELATED TO ALCOHOL, DRUGS, AND TRAFFIC SAFETY

Methods presently available for the evaluation of the effectiveness of mass media messages promoting traffic safety are discussed. Also, the design of effective mass communication campaigns, the comparative effect of such traffic accident countermeasures as legislation and enforcement, and possible future countermeasures are considered. The goals of any safety publicity campaign (a reduction in accidents and the accident-causing factors and an increase in public awareness of the problems, laws, and message involved) are discussed. Attention is given to the problem of drunken driving where safety campaigns have had questionable effectiveness. The value and limitations of research into mass communications effectiveness are discussed. Operational research involving field experimentation and studies is considered the best method for determining how to effect behavioral change through mass communications. The following recommendations are made: that laws address themselves more to the problems of human interaction in which drinking takes place (to such concepts as accessory to the act or co-responsibility), the blood alcohol concentration levels necessary for prosecution must be set at high levels and punishment be fast and in accordance with public opinion; enforcement need not necessarily be increased because of the possibility of creating resentment toward the police and the law; there should be more immediacy between the message and the relevant situation (warning messages on liquor bottles or in bars); all aspects of any legislative countermeasure should be well publicized; more effort should be made in general to publicize the contributing factors behind accidents so that individuals do not have to learn the hard way; and the general public and law makers should be made well aware of whatever is scientifically known about accident causation to reduce the likelihood of ineffective or injudicious countermeasures.

by G. J. S. Wilde  
Queen's Univ., Dept. of Psychology, Kingston, Ontario, K7L  
3N6 Canada  
1974 ; 39p 40refs  
Presented at the Sixth International Conference on Alcohol,  
Drugs, and Traffic Safety, Toronto, Canada, 8-13 Sep 1974.  
Availability: Corporate author

HS-017 371

### TRAFFIC SAFETY

A general summary of traffic safety information is presented, including: the cost of crashes; why traffic safety; news and information about losses; alcohol and driving equals danger; are roads safe; community and state safety programs; safety stan-



February 29, 1976

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dards and programs; automobile safety features; looking for safety equipment; how to wear safety belts; checking your vehicle; tire safety; vehicle design and checks; knowing the distances required for stopping; riding a bike safely; knowing traffic signs; community safety and the citizen; a summary description of the motor vehicle safety standards; and resources for traffic safety.

by Charles W. Wixom; Stephen L. Oesch  
Boy Scouts of America, North Brunswick, N. J. 08902  
Rept. No. Boy Scout Merit Badge Pamphlet 3391 ; 1975 ; 68p  
refs  
Availability: Corporate author

HS-017 372

**COMMERCIAL VEHICLE BRAKING AND HANDLING. PROCEEDINGS OF A SYMPOSIUM, MAY 5-7 1975, ANN ARBOR, MICHIGAN**

A symposium on commercial vehicle braking and handling, sponsored by the Highway Safety Research Institute of the University of Michigan, was held to provide a review of the state of the art in commercial vehicle braking and handling. It was also designed to provide a forum for communicating ideas and concerns over simulation-related responses during braking in commercial vehicles, for various research organizations, industrial operations, and government agencies. There were four technical sessions: measurement of commercial vehicle tire properties; brake and antilock system performance; topics in computer simulation; and an overview of simulation and testing; followed by a panel discussion on the effects of government standards on commercial vehicle braking and handling. These discussions are contained in this report.

University of Michigan, Hwy. Safety Res. Inst., Ann Arbor, Mich.  
Rept. No. UM-HSRI-PF-75-6 ; 1975 ; 595p refs  
In cooperation with the Univ. of Michigan Extension Service.  
Includes HS-017 373--HS-017 391.  
Availability: University of Michigan Press, Publication Distribution Service, 615 E. Univ. Ave., Ann Arbor, Mich. 48104 \$10.00

HS-017 373

**TRUCK TIRE TESTING ON TIRF**

The Calspan Tire Research Facility (TIRF) as a laboratory apparatus for testing truck tires is composed of a 28-inch wide roadway made up of a stainless steel belt covered with material that simulates the surface texture and frictional properties of actual road surfaces. It can measure tire positioning, tire-wheel drive, balance, traction on dry and wet pavements and dual tire results. Test results are shown for a combined lateral slip and longitudinal slip operations for a 10.00 x 20 truck tire on wet and dry surfaces. On dry pavement, the interval between time of brake application to lock-up was about 0.5 seconds. Aligning torque is positive at positive slip angle with no braking. Application of the brakes and development of braking force leads to large negative aligning torques. For grooved tires on wet surfaces it was shown that at speeds of 20 mph, the grooves provided necessary drainage, which became increasingly inadequate as speeds increased. Dual tires were tested in the same fashion as single tires. Lateral force co-efficients of the two types of tires were virtually identical for all slip angles tested, unless they were generated by tire cambering rather than side-slipping. Limitations of the TIRF

facility are that the upper limits of load and brake force are well below those desirable to evaluate tire-vehicle systems with respect to proposed Federal Motor Vehicle Safety Standards; and increasing the braking capabilities of the facility would be expensive.

by K. D. Bird; D. J. Schuring  
Calspan Corp.  
Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p3-39  
1975 ; 8refs  
Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.  
Availability: In HS-017 372

HS-017 374

**MOBILE MEASUREMENT OF TRUCK TIRE TRACTION**

A mobile dynamometer system was developed for use in measuring the lateral and longitudinal traction properties of truck tires on actual paved surfaces. The longitudinal traction dynamometer is a welded trailer structure of pipe and plate sections, with a test wheel supported by a parallelogram suspension. The suspension configuration derives from attempts to achieve: the elimination of kinematic interactions between the loads applied to the test wheel and resulting shear forces and moments; the employment of a low-spring rate loading mechanism; and the minimization of the value of the unsprung mass. Tests are repeated over a range of loads, velocities, pavements, and tire samples. Two asphalt and two concrete surfaces were used. While there appeared to be a changing rank among the surfaces in terms of the peak and slide traction values, the two asphalt surfaces generally provided higher peak traction performances than did the two concrete surfaces. More experimental work should be done, however, and expanded to include angular slip and combined slip portions of the traction field so that a comprehensive understanding of the critical truck component can be developed.

by R. D. Ervin  
University of Michigan, Hwy. Safety Res. Inst.  
Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p41-75  
1975 ; 5refs  
Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.  
Availability: In HS-017 372

HS-017 375

**MEASUREMENT AND PREDICTION OF COMMERCIAL VEHICLE BRAKE TORQUE**

A new test vehicle was developed to measure time histories of brake torque over-the-road at nearly constant velocity. The brake test device makes use of a modified tractor-trailer and associated apparatus, outfitted with modular items to supply electric and hydraulic power, and an operator's station. It is capable of handling up to 20,000 pounds of vertical load and 240,000 inch-pounds of brake torque. Four truck air brakes were used in an initial test program which included tests to assess the influence of brake pressure, rubbing speed, and drum temperature on brake torque. Special tests were included to measure hysteretic effects. The findings from the data indicate: drum-shoe rubbing speed is an important factor influencing the brake torque obtained at given pressure; initial

drum temperatures in the 200-500° F range have little influence on the level of brake torque; and the data generated in this study indicates that the rate of energy input to the drum is the more pertinent factor, i.e. the time history of the change in temperature is more important than the change itself. Based on these findings, a semi-empirical brake fade model was developed in which torque is assumed to vary linearly with the temperature change at the lining/drum interface.

by T. M. Post

University of Michigan, Hwy. Safety Res. Inst.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p77-102

1975 ; 6refs

Presented at a Symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 376

### **SIMULATION IN ANTILOCK SYSTEM DEVELOPMENT**

The use of computer simulation in the development of antilock systems for air-braked vehicles is discussed. The development of basic equations and relationships between the brake, wheel, vehicle and tire-road interface were made possible by analysis of the factors involved in the operation of anti-lock braking. Components significant to antilock brake system performance are the brake modulator, brake characteristics, wheel dynamics, vehicle dynamics, speed sensor and control logic. Slippage between tire and the road is defined where slip equals 100 times vehicle velocity minus wheel velocity divided by vehicle velocity. Wheel load and the tire-road friction coefficient combine to produce the braking force, and in turn the vehicle deceleration and stopping distance. Different antilock systems were developed using simulation models for concept development: a single-wheel type; a two wheel type to measure vehicle characteristics; and a detailed part-by-part mathematical model of the brake modulator for an optimization effect. The systems were then vehicle tested. Comparison of simulation and test data showed that the simulations were effective in predicting qualitative performance and relative performance levels of the different systems. It has also been demonstrated that optimization of the system parameters can be accomplished using these various simulation models.

by G. A. Cornell; B. E. Latvala

Bendix Corp.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p103-17

1975

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 377

### **A GENERAL-PURPOSE SIMULATION FOR ANTISKID BRAKING SYSTEMS**

A general purpose digital computer program for simulating the wheel sensor, control logic, and pressure modulator characteristics of antiskid systems was developed. The simulation concentrates on: wheel sensor, (a phase shift and/or time delay between the actual wheel rate and the derived wheel rate); control logic, characterized by a set of eight inequality expressions formed as necessary conditions for On and Off

signals; adaptive coefficients; side-to-side options for worst wheel, best wheel and average wheel; logic sampling rate control which controls the rate at which the antilock logic is interrogated; and pressure modulator valve, which is simulated by two time delays and programmable rise and fall rates for both exponential and linear characteristics. Laboratory simulation results demonstrated the capability and potential of the program for simulating the various features and behavior associated with different anti-lock systems. A dictionary of pertinent antilock variables and parameters is included in order to offer flexibility to the program user in regard to variable and parameter programming choices.

by C. C. MacAdam

University of Michigan, Hwy. Safety Res. Inst.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p119-58

1975

Presented at a Symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 378

### **TESTING FOR FMVSS 121--A DISCUSSION OF RESULTS [ANTI-LOCK BRAKE SYSTEMS]**

A discussion of results on testing for Federal Motor Vehicle Safety Standard 121 revealed the following conclusions: on anti-lock equipped vehicles with brakes sized sufficiently to produce wheel lockup, the stopping distance capabilities are primarily controlled by the function of the anti-lock system in use and the peak traction characteristics of the tires; anti-lock systems tend to deliver lower average retardation and longer stopping distances with increasing brake overtorque and/or faster air timing; the basic factor determining the stopping capabilities of a vehicle is the peak tire traction available from each axle's tires under dynamic load conditions; scatter in stopping distance test results increases with increasing initial speed. This effect has been traced to increasing effect of anti-lock system activity, and variations in this activity, as speed increases; vehicle simulation using computer techniques shows significant promise as a means of brake sizing and evaluation for compliance with stopping performance requirements of imposed standards; anti-lock systems can be concluded to be a beneficial addition to truck brake systems; the present stopping distance requirements of the standards are too stringent with respect to observed variations in test results. The variations occur for reasons neither accounted for in the provisions of the standards, nor controllable by the vehicle manufacturer.

by C. W. Booth

Paccar, Inc.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p159-91

1975 ; 1ref

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 379

# **AN EVALUATION OF ANTILOCK SYSTEM PERFORMANCE ON HEAVY DUTY AIR BRAKED COMMERCIAL VEHICLES**

Performance test results of heavy duty air braked vehicles equipped with various wheel antilock control systems are presented. These tests compared both the straight-line stopping capability and the limit of lateral stability of vehicles equipped with antilock systems from six manufacturers. Results from comparisons of the systems show that no single antilock system performed "best" overall. Significant performance variations occurred as a result of vehicle configuration, loading, test surface, and test speed. In addition, these tests showed the existence of a significant performance trade-off between straight line dry asphalt stopping distance and lateral stability provided by each antilock system. Additional factors affecting the antilock system performance were brake retardation force and brake actuation time. When brake retardation force was increased above the level required to produce incipient wheel lockup, stopping distance was also increased. Since the margins between Federal Motor Vehicle Safety Standard-121 stopping distance requirements and actual stopping distances for many classes of vehicles can, in certain cases, be small, the supposed numerically insignificant effects which brake lining effectiveness, brake power, and actuation time have upon the performance of antilock systems cannot be ignored if consistent compliance with the 60 mph, 245 foot stopping distance requirement is to be assured. Test results indicate that the employment of currently available technology in the design and manufacture of brake control systems has not produced systems which can allow for significant variations in vehicle configuration, loading, test surface traction properties, and test speed, such that uniform performance is achieved.

by J. M. Ehlbeck; R. W. Murphy  
Freightliner Corp.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p193-219 1975

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 380

# **NHTSA/APL HYBRID COMPUTER VEHICLE HANDLING PROGRAM**

NHTSA currently has a simulation which predicts the dynamic response of motor vehicles to braking and steering commands, as well as aerodynamic and road roughness disturbances. The simulation model equations are solved simultaneously on an analog computer and a digital computer yielding a hybrid computer solution to the model. Simulation control is exercised via a cathode ray tube and keyboard terminal with complete interactive operation available for data manipulation, data collection, and run control. The interactive terminal does not have to be located at the hybrid computer and thus remote simulation operation is feasible. The Hybrid Computer Vehicle Handling Program has demonstrated realistic dynamic simulations of vehicles with various suspension configurations: front and rear independent; independent front with solid rear axle; solid front and rear axles; and solid front and rear axles with dual rear tires. The performance of simulation runs was inexpensively and easily performed. In addition, the performance

measuring vehicle Comparison variables for a Dodge Coronet, a Chevy Brookwood, a Pontiac Trans Am, and a VW Super-beetle, are provided.

by P. F. Bohn; R. J. Keenan

Johns Hopkins Univ., Applied Physics Lab.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p221-43 1975 ; 10refs

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 381

# **TIRE FRICTION MODELS AND THEIR EFFECT ON SIMULATED VEHICLE DYNAMICS**

Tire friction models are examined. Tire friction is considered as a function of: tire/road friction coefficient; slip angle; slip ratio; normal load on tire; and tire translational speed. Tire camber is considered to be zero. Emphasis is placed on the tire side force and a numerical comparison is illustrated. All simulation results contained errors when compared with experimental vehicle response. The common error arises from over-simplification of vehicle dynamics. A number of conclusions can be drawn: significant differences in vehicle motions predicted by different models demonstrates the necessity for an accurate model over the entire operating regions of slip angle, slip ratio, vehicle speed, and the factors comprising tire friction; vehicle yaw acceleration varied with the difference between the tire lateral forces at the front and rear wheels; the tabular-data-model gives a representative vehicle response, although not necessarily the most realistic one when compared with actual vehicle response; there is no unique relationship between the maximum angle, the maximum side force, and the lateral stiffness, that can be established; a cubic fit for the lateral force versus slip angle curve is found to be superior over a quartic one; the use of the friction ellipse concept is critical for braking-in-a-turn maneuvers and the computing time for Dugoff's model (which is an alternative to the tabular-data-model) is the shortest used in the simulations, thus proving the advantage of a closed-form formula for tire frictional forces.

by P. K. Nguyen; E. R. Case

Ministry of Transportation and Communication, Ont., Canada

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p245-312 1975 ; 19refs

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 382

# **APPLICATION OF GENERAL RIGID BODY DYNAMICS TO VEHICLE BEHAVIOR**

The application of a 4 by 4 matrix method to simulate the behavior of articulated highway vehicles is presented. The method requires that a model of the vehicle be adopted and that data concerning the characteristics of the model be specified--the digital computer is used to represent numerically and to solve exactly the differential equations that govern the behavior of the vehicle model. The method is applied to simulating the behavior of several articulated vehicles. Results are first given for the predicted behavior of a tractor-semi-trailer

truck. The results are then compared with those obtained from a previously developed tractor-semi-trailer model. The comparison will show any error in the previously developed model. When the effect of this error is eliminated, the results obtained from both models are nearly identical. The method is then used to obtain the predicted behavior of several different articulated vehicles for a cornering maneuver with and without braking. Three mathematical models were given. The first was an existing modified model having massless beam-axle suspension systems. The second was obtained using the subject method with massless beam-axle-suspension systems. The third was obtained using the subject method with beam-axes having mass. Each test started with the vehicle moving at a constant forward velocity, with all other state variables initially zero. At time equal to zero seconds, a step steering angle of 0.01 radians was applied to the front wheels, no braking was applied. As a result of using this method, it was demonstrated that the simulated behavior of many different types (configurations) of vehicles can be obtained with relative ease.

by A. I. Krauter; W. E. Tobler  
Shaker Res. Corp.; Cornell Univ., Sibley School of  
Mechanical and Aerospace Engineering  
Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle  
Braking and Handling, Ann Arbor, Mich., 1975 p313-52  
1975 ; 9refs  
Presented at a symposium held in Ann Arbor, Mich., 5-7 May  
1975.  
Availability: In HS-017 372

HS-017 383

#### THE INFLUENCE OF TIRE MODELING IN COMMERCIAL VEHICLE SIMULATION

Predicted vehicle rolling motion depends on the manner in which the tires are represented. Including various amounts of tire lateral flexibility affects both the predicted roll frequency and damping. Reducing tire lateral stiffness reduces the predicted roll frequency. Omitting the tire lateral flexibility introduces a 10% error into the roll frequency and 20% in the damping. Increasing the lateral flexibility ten fold approximately halves the roll frequency and damping. It must be concluded therefore that the approximations involved in the representation of tires solely in terms of slip angles can produce unacceptably large errors in the case of commercial vehicles.

by C. G. Shapley  
Firestone Tire and Rubber Co.  
Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle  
Braking and Handling, Ann Arbor, Mich., 1975 p353-69  
1975 ; 2refs  
Presented at a symposium held in Ann Arbor, Mich., 5-7 May  
1975.  
Availability: In HS-017 372

HS-017 384

#### HANDLING DYNAMICS OF AN INTERCITY BUS

It is demonstrated that full-scale tests can be used to assess handling performance limits, and that the associated simulation provides an adequate model of the nominal handling and limit performance characteristics of the vehicle. A Motor Coach Industries Model MC-7 bus, with solid I-beam front axle, dual wheel rear axle, and single rear trailing wheel on each side was used. Performance limits for: rollover, spinout; and plow

out; were used for interpreting overall handling parameters. For turning and braking maneuvers on dry pavement, results were not clear. The experiments show a dramatic difference in the limit performance between wet and dry coefficient surfaces. In the wet, rollovers are less likely, and the vehicle either spins or plows out. On a dry surface, the typical performance with a relatively topheavy commercial vehicle is rollover, if the lateral acceleration is sufficiently large. Although the existing simulation is extensive in detail, there were several ways in which it might be usefully extended for certain applications. The front suspension could be replaced by independent suspension; and different rear axle geometries could be employed. The simple steering system of the existing equations could be elaborated upon to include the dynamics and nonlinearities of a power steering box, and tie rod ends. Aerodynamic terms should be added to permit study of the effects of crosswinds and aerodynamic disturbances.

by G. L. Teper; D. H. Weir  
Systems Technology, Inc.  
Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle  
Braking and Handling, Ann Arbor, Mich., 1975 p371-406  
1975 ; 6refs  
Presented at a symposium held in Ann Arbor, Mich., 5-7 May  
1975.  
Availability: In HS-017 372

HS-017 385

#### THE MODELING AND TESTING OF ARTICULATED VEHICLES AT THE SCHOOL OF AUTOMOTIVE STUDIES, CRANFIELD

Development of articulated vehicle studies at the School of Automotive Studies, Cranfield is outlined, with references to various publications in the field, which originated at the School. The initial work culminated in "The Dynamics of Vehicles During Braking" which represented the first analysis of an articulated vehicle to incorporate variable forward speed and could accommodate large articulation and slip angles. Another study used the vehicle model (a single drive-axle tractor with a single axle semi-trailer) to demonstrate the effect of road camber on the braking performance. Front wheel locking on an inclined surface was specifically investigated. A third study examined characteristic frequency equations to demonstrate vehicle stability at various configurations. A further test to validate simulations, examined a vehicle at rest; ride motions at zero forward speed; steady state; and transient response. Current work at the School aims to produce a suite of programs of varying complexity to cover a wide range of vehicle configurations.

by J. R. Ellis; P. L. Read  
Cranfield Inst. of Tech., School of Automotive Studies  
Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle  
Braking and Handling, Ann Arbor, Mich., 1975 p407-18  
1975 ; 8refs  
Presented at a symposium held in Ann Arbor, Mich., 5-7 May  
1975.  
Availability: In HS-017 372

HS-017 386

#### THE ROLE OF ANALYTICAL TECHNIQUES IN THE FORMULATION OF VEHICLE SAFETY STANDARDS

Analytical techniques can be used as tools for the development of safety standards. These techniques have been



validated for use in the development of criteria and levels in safety standards. The results of these techniques, however, should be tempered somewhat by human judgment. Analytical techniques can be used to conduct sensitivity and parameter studies in vehicle design and evaluation. In addition, meaningful test programs can be developed with the aid of analytical techniques. They should also be used in the future, along with full scale testing, to aid in the development of realistic safety standards based on present technology.

by Ronald L. Eshleman

Vibration Inst.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p419-37 1975

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 387

### PREDICTION OF BRAKING AND DIRECTIONAL RESPONSES OF COMMERCIAL VEHICLES

A State-of-the-art survey shows that a great deal of truck mechanics research is yet to be done. The need for further tire studies, and equipment for making truck tire measurements, is seen. The mechanical friction brake does not appear to be well understood. Test experience indicates that the performance of a given commercial vehicle brake varies with past work history during a series of repeated brake applications. This variability has not been explained but its presence can make it difficult to obtain repeatable vehicle test results. Clearly it will hinder any attempt to validate a simulation with a limited number of vehicle tests. The use of antilock braking systems on commercial vehicles increases the complexity of the simulation problem. Efficient, simple means for representing antilock systems are needed. Future expectations include involvement in vehicle test activities and antilock performance studies aimed at making the Highway Safety Research Institute at the University of Michigan more effective in predicting the longitudinal and directional response of commercial vehicles.

by P. S. Fancher, Jr.

University of Michigan, Hwy. Safety Res. Inst.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p439-62 1975 ; 18refs

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 388

### SAFETY PROBLEMS IN COMMERCIAL VEHICLE HANDLING

Swedish research on the dynamic behavior of heavy vehicle combinations and proposed regulations on handling performance included: double lane change tests; overturning limit in steady state cornering; low speed off-tracking; double lane change maneuver behavior; steady state overturning limit; low speed off-tracking; and steady-state high speed off tracking. Research was concentrated on the handling performance in a double lane change maneuver studied by means of digital computer simulation. The 10 degrees-of-freedom driver-vehicle simulation model used in the studies was validated by full

scale tests. Several studies on overturning stability were performed, such as: full scale static tests; lateral sloshing effects studied by means of servo-operated scale models connected to an analog computer; studies of relations between driver estimated and calculated overturning risk in real traffic. The low speed off-tracking problem was investigated separately. Performance criteria were chosen in close relation to accident risk. Simulation results indicate that the rearmost unit of an articulated vehicle has the highest risk factors. Important design parameters include: number of articulations; steered axle location; tire data, geometric configurations, load condition, and roll stiffness. For road tankers with laterally sloshing liquid, the overturning risk can be more than twice the risk with corresponding rigid load. Regulations proposing improvements in vehicle design such as: placing the tow pin ahead; avoiding large overhangs; utilizing maximum lateral distance between springs; utilizing anti-roll bars; eliminating sloshing by a piston arrangement in each tank that will be partially loaded; and using the space between axles and wheels to lower the center of gravity, are recommended.

by L. Strandberg; O. Nordstrom; S. Nordmark

National Swedish Road and Traffic Res. Inst.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p463-528 1975 ; 25refs

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 389

### ARTICULATED VEHICLE RESEARCH IN ONTARIO

An overview of the commercial vehicle research program undertaken by the Province of Ontario to improve the highway safety of articulated vehicles is presented. Accident statistic examination determined the extent of various causes of accidents; vehicle instability; mechanical deficiencies, and driver oriented causes. The research program is being developed around the need for safety regulations identified by accident data and vehicle inspections. The process of defining acceptable vehicle performance in terms which can be translated into enforceable licensing regulations and inspection procedures is emphasized. A pragmatic approach, in which experimental results from vehicle tests and theoretical results from computer simulations can be used to predict acceptable performance criteria for a wide variety of conditions, is proposed. Articulated vehicle research was pursued along two main lines; mechanical and structural integrity of load attachment and articulation components; and vehicle dynamics and maneuverability as dependent on vehicle configuration. Vehicle dynamics should provide a more thorough understanding of the articulated vehicle as a complete operating system.

by F. B. Snelgrove

Ministry of Transportation and Communications, Downsview, Ont., Canada

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p529-61 1975

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 390

HS-017 390

### FEDERAL FOLLY--PUBLIC POLICY WITHOUT RESEARCH

There seems to be an antagonism between industry and government that has created a mutual distrust. Possible reasons may be: the hasty imposition of Federal standards without extensive research; and government mistrust of industry's motives. Focus has been shifted to different areas, particularly in the automotive industry's case, without a clear look at the total impact of imposing regulations. Proper research and analysis could have allowed informed and sensible understanding on both sides of the question. There is a need for regulations, most certainly, but to begin to define and draw up regulations without complete and proper research can lead to serious problems. Mass media helps to determine public policy, and controversy is given a good share of attention, most of it being anti-industry. It is suggested that individuals--in business, government or the academic world--recognize not only the right to say what they feel, but also the responsibility they have in changing or serving public opinion.

by William D. Eberle

Motor Vehicle Mfgs. Assoc.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p563-74

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HS-017 391

### SYMPOSIUM ON COMMERCIAL VEHICLE BRAKING AND HANDLING. FORMAL REMARKS AND PANEL DISCUSSION

Three subjects were presented for panel discussion: a suggestion that industry and government work together to resolve truck brake problems; a brief description of the general behavior of tractor-trailer combinations; and the National Highway Traffic Safety Standards. Revolutionary modifications in front axle and suspension design, for example, necessitated by Federal Motor Vehicle Safety Standard 121, suggests that there was little awareness of the consequences of requiring short stopping distances for trucks and tractors. It is now essential to apply high levels of front brake axle torque to commercial vehicles in development programs. Vehicle manufacturers and their suppliers have made contributions available for ultimate resolution of a practical combination of regulations and good vehicle handling which include: more brake torque; more rugged suspensions; modified steering; skid control systems (anti-lock); responsive air systems; and massive amounts of test data. A list of attendees of the Symposium concludes the Proceedings on Commercial Vehicle Braking and Handling.

by A. G. Beier; Eugene Chosy; John W. Kourik  
International Harvester, Brake Components Sec.; Fruehauf Corp., Reliability and Quality Assurance; Wagner Electric Corp.

Publ: HS-017 372 (UM-HSRI-PF-75-6), Commercial Vehicle Braking and Handling, Ann Arbor, Mich., 1975 p575-89

Presented at a symposium held in Ann Arbor, Mich., 5-7 May 1975.

Availability: In HS-017 372

HSL 76-02

HS-017 392

### RAW MATERIAL SOURCES FOR AUTOMOTIVE PLASTICS

The sources of raw materials available for production of the major automotive plastics have been determined. In order to do this, each polymer was broken down into its monomeric units, and the basic chemicals used in the commercial syntheses of each monomer were specified. The major automotive plastics are: poly(acrylonitrile-butadiene-styrene); poly(vinyl chloride); polyethylene; polyurethane; polyester; polypropylene and polyamides. Three raw material sources are: coal, which is a source of chemicals such as acetylene, needed for polymer production; oil shale; and agricultural products which can be used to provide ethyl alcohol and furfural. It is concluded that chemicals necessary for the manufacture of plastics that do not have an alternative synthetic route are available in quantity from oil shale and coal. Coal can be used as a sole source of all necessary basic chemicals for the production of automotive plastics. Oil shale can supply benzene, propylene, and ethylene. Agricultural products can be used to make substitute polymers.

by Zack G. Garlund

General Motors Res. Labs.

Rept. No. SAE-750187; 1975; 11p 20refs

Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.

Availability: SAE

HS-017 393

### THE DOT/SAE TRUCK AND BUS FUEL ECONOMY MEASUREMENT CONFERENCE. ANN ARBOR, MICH., APRIL 21-23, 1975

A conference conducted to develop measurement techniques which may be useful in a joint industry-government voluntary truck and bus fuel economy implementation program is reported. An overview is presented giving the objectives and goals of the conference, and the government and the industry viewpoint. Reports are presented of studies conducted to establish vehicle duty cycles to be used in determining the representative fuel economy performance of commercial vehicles in: a long haul cycle (intercity travel with one-way haul of more than 200 miles, general-use for 10-15 hours in 24-hour day, five days out of a week, or 90% of miles traveled rural); a short haul cycle (maximum haul of 200 one-way miles at 20-35 mph average for all classes of vehicles); and a local cycle (frequent stop-and-go operation of buses and trucks, not excluding utility vehicles in stationary use). The work of other task forces with the following objectives is reported: to develop a medium and heavy-duty truck and bus categorization system that is based upon user and manufacturer experience; to provide a technique for reporting fuel economy under specified vehicle classifications and duty cycles; to develop a fuel measurement test procedure for basic engines applied to on-highway applications which can be logically related to fuel measurement formulation procedures; to provide a method of measuring and comparing fuel consumption of engine-driven accessories required by the truck and bus user; to outline and specify methods for determining the influence of aerodynamics on the fuel economy of buses and trucks of 10,000 pounds or greater; to determine techniques for measuring rolling resistance of tires and wheels and for relating information to overall fuel economy; to provide a means of evaluating trucks and bus drivelines, components and modifi-

cations to determine the effect of complete driveline and components on fuel consumptions; to consider the factors involved in developing test procedures to be used in evaluating fuel economy for trucks and buses over 10,000 pounds; and to determine a tool to predict relative fuel consumption of vehicle alternatives.

SAE Res. Executive Board  
Rept. No. SAE-P-59 ; 1975 ; 336p refs  
Supported by U.S. Department of Transportation. Includes SAE Standard J816b, "Engine Test Code--Spark Ignition and Diesel"; SAE Recommended Practice J745c, "Hydraulic Power Pump Test Procedure"; SAE-690108, "Low Power Loss Tires" by W. W. Curtiss; SAE Standard J643a, "Hydrodynamic Drive Test Code"; SAE Standard J651b, "Passenger Car Automatic Transmission Test Code"; and SAE Recommended Practice J652, "Truck Transmission Test Code."  
Availability: SAE

HS-017 394

### THE EFFECTIVENESS OF AUTOMATIC PROTECTION IN REDUCING ACCIDENT FREQUENCY AND SEVERITY AT PUBLIC GRADE CROSSINGS IN CALIFORNIA

To assist the California Public Utilities Commission in administering State funds and developing priority lists for Federal funds, a project was undertaken to determine: the scope of the railroad-highway grade crossing problem in California; the effectiveness of automatic protection in reducing vehicle-train accidents; the comparison of installation cost of different types of automatic protection devices; and the development of criteria to assist in placing grade crossing protection improvements. A questionnaire was sent to all cities and counties to determine the scope of the problem. A comparison was made of installation cost reports for the period 1966 to 1973. In order to develop criteria, 115 grade crossings presently protected by automatic devices were selected at random for examination. To determine the effectiveness of automatic protection devices in reducing train-automobile accidents, a study was carried out using accident records and accident histories of 1,552 grade crossings using protection devices. The following results were found: installation of automatic protection devices can result in an average 69 percent reduction in the number of vehicle-train accidents; installation costs of both flashing lights and automatic gates have increased since 1966 and requires a fairly costly yearly maintenance. Results from the questionnaire show that factors affecting the decision to install protection include: annual average daily traffic; number of daily trains; corner visibility; vehicular speed; train speed; acute angle of intersection; conditions of crossing; approach grade; roadway curvature; and number of traffic lanes.

California Public Utilities Commission, Railroad Operations and Safety Branch, San Francisco, Calif.  
1974 ; 219p 102refs  
Supported by the State of California Office of Traffic Safety and the National Hwy. Traffic Safety Administration.  
Availability: Corporate author

HS-017 395

### LOCOMOTIVE TO AUTOMOBILE BASELINE CRASH TESTS. FINAL REPORT

Four locomotive to automobile crash tests were performed to obtain baseline data for evaluation of future locomotive front structure modifications designed to refine the severity of grade crossing accidents. The automobiles were all 1973 standard size four door sedans of the same model with similar options. For each test, a 130-ton Alco locomotive impacted a stationary automobile at a nominal 50 mph. The first two tests contained no instrumentation on either the locomotive or automobile except for high speed cameras. The last two tests were instrumented repeats of the first two tests, except for the addition of approximately 600 pounds of accelerometers and an anthropomorphic dummy. The last two tests also involved a direct side impact and a side impact centered on the automobile front fender. Each test had extensive high frame rate photographic coverage. Similarities were noted for tests 1 and 3 as follows: rear door window on driver's side broke at same time; front door window on driver's side broke within 1 millisecond; rear window broke within 3 milliseconds; front plate of locomotive contacted with car within 4 milliseconds; recognition of shearing of trunk was noted within 6 milliseconds; front seat buckled at same time; rear window sill and sill level of car post buckled at same time; buckle formed in roof within 2 milliseconds; windshields broke at the same time; trunk lid buckled open with 4 milliseconds; and right front fender separation occurred within 6 milliseconds. For vehicles 2 and 4, the following similarities were noted: locomotive front plate contacts left front door within 1 millisecond; locomotive front plate contacted front bumper within 1 millisecond; front windshield broke within 1 millisecond; driver window broke within 10 milliseconds; automobile observed parallel to track within 35 milliseconds; left front fender and hood separated from firewall within 110 milliseconds. Overall performance of automobiles was similar, and in all cases damage to the dummy was in the fatal range. Recommendation for improvements of the restraint systems and structural strengths of the automobile, as well as a deformable structure or shock absorber on the front of the locomotive that will yield at a low force over a large enough distance to allow the automobile to achieve the locomotive velocity, were made.

by R. L. Anderson  
Dynamic Science, Div. of Ultrasystems, 1850 West Pinnacle Peak Rd., Phoenix, Ariz. 85027  
Contract DOT-TSC-700  
Rept. No. FRA-OR & D-76-03; DOT-TSC-FRA-75-18 ; 1975 ; 148p  
Rept. for Nov. 1973-Jun 1974. Sponsored by the Federal Railroad Administration.  
Availability: NTIS

HS-017 396

### AIR BAGS AND OUT-OF-POSITION CHILDREN. A SURVEY

In a survey conducted at 14 amusement areas and shopping centers in Maryland, Massachusetts, and Virginia in 1974, 93% of 8,893 children less than 10 years of age observed in automobiles were travelling without restraints or were improperly restrained against possible crash injuries. Of the children using seating devices, 75% were either inadequate devices or were being used improperly. The findings suggest that children travelling in motor vehicles need "passive" pro-

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tection, such as air bags, which work automatically and do not require the child or his parents to take any action in order to protect the child in a crash. A survey was undertaken in order to determine the positions in which unrestrained children travel in vehicles. Visual observations were made on the positions of 4,602 passengers estimated to be less than 10 years old in 3,149 automobiles. Of the 4,602 children observed, only 3% were observed in types of front seat positions in which air bags would afford protection. A recent technological development by Nissan Co., Ltd. has presented a bi-level air bag on the passenger side affording protection for the standing child in which the inflator for the air bag on the passenger side will not operate more than halfway if the passenger seat is unoccupied. General Motors and Olin Corporation also offer results from air bag tests for standing children with systems that include variable inflation which produces a less direct impact on the head and upper torso of a child.

by Allan F. Williams  
Insurance Inst. for Hwy. Safety, Watergate 600, Washington,  
D.C. 20037  
1975 ; 7p 11refs  
Prepared for publication in Accident Analysis and Prevention.  
Availability: Corporate author

HS-017 397

# 1973 ACCIDENTS OF MOTOR CARRIERS OF PROPERTY

Information is furnished based on accident report forms submitted by Motor Carriers of Property who operated in Interstate or Foreign commerce for 1973. Information concerning accidents, fatalities, injuries and property damage, is subdivided into: carrier type; accident type within each carrier type; and type of trip within each accident type. Broadly speaking, the carriers were either: private, from firms which haul freight owned by another party; or for-hire which are either local or over-the-road. In a recent census it was found that over 60% of the motor carriers under the jurisdiction of the Federal Motor Carrier Safety Regulations are private, but that private carriers account for only 17% of all accidents reported in 1973, as well as 19% of property damage and 23% of total fatalities. This is probably due to the fact that either private carriers tend to report only serious accidents, or not at all, possibly due to the fact that 1973 was the first year when private carriers were required to report accidents to the Bureau. In 1973 there were 30,911 accidents of all types reported, with 3,058 fatalities, 35,245 injuries and \$169.7 million in property damage. For-hire carriers accounted for 74% of the accident reports filed, 63% of the fatalities, 74% of the injuries and 71% of the property damage. Of those killed, 585 were truck drivers, 154 were other truck occupants, and 2,319 were others involved in the accident. Over-the-road collision accidents accounted for 58% of the total number of accidents; 77% of the fatalities, 64% of the injuries and 59% of the property damage. Over-the-road, non-collision accidents accounted for 20% of the accidents, 10% of the fatalities, 14% of the injuries, and 30% of the property damage. Of reported accidents 19% were local collisions, accounting for 12% of the fatalities, 22% of the injuries and 8% of the property damage. A separate study made of 3,179 authorized carriers that filed accident reports in 1973 showed that the carriers travelled 21.6 billion vehicle

miles; had 20,560 accidents, 1,541 fatalities, 21,954 injuries and \$99.4 million in property damage.

Federal Hwy. Administration, Bureau of Motor Carrier Safety,  
Washington, D.C. 20590  
1974 ; 73p  
Availability: Corporate author

HS-017 399

# ROLLING CHARACTERISTICS OF SMALL SIZE PNEUMATIC TYRES [TIRES]

The dynamic characteristics of single-track vehicles are predominantly governed by forces and moments of tire-pavement interaction. Free-rolling characteristics of Dunlop 3.50-8, Inchek 3.50-8, and Kicorma 3.50-8 and 3.50-10 were experimentally determined through the use of a flat-type tire testing machine developed in India. Effects of tread wear and rim size were also investigated. It was found that: for the slip angle, lateral force, aligning torque, and overturning moment, magnitudes increase nearly linearly; for the tire size, lateral force, aligning torque, and overturning moment increase with size; for the number of plies, lateral force increases with number of plies, aligning torque decreases with number of plies, and overturning moment decreases with number of plies; for the state of wear, lateral force, aligning torque, and overturning moment increase with wear; and for inclination angle, lateral force, aligning torque, and overturning moment increase nearly linearly. A combination of slip and inclination angles shows that slip angle and inclination angle with opposite signs give larger values than when they are both of the same sign for lateral force, aligning torque, and overturning moment. Normal force and correspondingly large inflation pressure is larger for larger values of lateral force and inflation pressure for lateral force, aligning torque, and overturning moment.

by D. V. Singh; V. K. Goel; M. Bhattacharya  
University of Roorkee, Dept. of Mechanical Engineering,  
Roorkee, U. P., India  
Publ: Institution of Mechanical Engineers, Proceedings,  
London, 1974 v188 n63 p701-13  
Rept. No. 63/74 ; 1974; 15p 12refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage  
Walk, London SW1H 9JJ, England

HS-017 400

# PITTING OF GEARS AND DISCS

Pitting tests using 127 mm (5 inch) centers distance gear rig under controlled conditions are described. They are compared with similar disc tests using the same materials and lubricants. Tests of both types confirm Dawson's conclusion that an important factor influencing pitting life is the ratio of surface roughness to the calculated lubricant film thickness. It has been shown that using a hunting tooth ratio, particularly when associated with a rough harder surface and a surface finish oriented normal to the motion, increases the likelihood of wear. Most importantly, the results show that using disc tests can greatly overestimate the pitting life of gears. These experiments and other evidence from the literature suggest that the

most probable reason for these differences between gears and discs lies in dynamic gear loads.

by R. A. Onions; J. F. Archard  
Admiralty Oil Lab., Cobham, Surrey, England; Dept. of Engineering, Univ. of Leicester, LE1 7RH, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n54 p673-82  
Rept. No. 54/74 ; 1974 ; 13p 21refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 401

# **CHARACTERISTICS OF EXTERNALLY PRESSURIZED JOURNAL BEARINGS WITH MEMBRANE-TYPE VARIABLE-FLOW RESTRICTORS AS COMPENSATING ELEMENTS**

The characteristics of externally pressurized journal bearings with four recesses and with membrane-type variable-flow restrictors as compensating elements are analytically investigated by using the bearing model of Raimondi and Boyd. The results can be useful in predicting the effects of membrane compliance on the stiffness load capacity of the bearing. For a non-rotating shaft, it is shown that when the bearing operates at zero eccentricity there is a pressure ratio that gives an optimum bearing stiffness. In general, the results indicate that for a given bearing geometry the load capacity and stiffness of the bearing are strongly dependent upon the membrane compliance, the pressure ratio, and the eccentricity ratio. For a given eccentricity ratio, the geometric and operating parameters for which the bearing has good stiffness characteristics are not necessarily the same as those for which the bearing has a good load capacity. In addition, membrane compliance that gives a good bearing stiffness at a given pressure ratio, for a given eccentricity, may give poor stiffness characteristics for a bearing operating at the same pressure ratio, but at a different eccentricity. Thus, an "optimum" membrane compliance, as described by the original work of De Gast on this problem for a bearing operating at zero eccentricity, may not be the best value if the operating eccentricity is not near zero.

by C. Cusano  
University of Illinois at Urbana-Champaign, Dept. of Mechanical and Industrial Engineering, Urbana, Ill.  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n52 p527-36  
Rept. No. 52/74 ; 1974 ; 12p 25refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 402

# **STEADY AND NON-STEADY FLOW IN A SAMPLE CARBURETTOR [CARBURETOR]**

Steady and non-steady flow through a carburetor represented by an adiabatic pressure loss at a discontinuity in the intake system of an engine is investigated. It was shown that the simple model used gave an excellent prediction of the pressure-time development in the intake system except at small throttle openings where there was some error in the peak amplitude. Mass flow and trapped mass predictions were excellent. The results show that pressure drop may be less under non-steady flow than under steady flow, since the dynamic coefficient may be less than unity. Some improvement in the model may be obtained if allowance is made for the asymmetry of the

flow downstream of the throttle plate, since it is shown by diagrams presented in the study that upstream pressure predictions are better than the downstream predictions.

by R. S. Benson; P. C. Baruah; R. Sierens  
University of Manchester Inst. of Science and Technology, Manchester M60 1QD, England; Univ. of Gent, Lab. for Machines and Construction Machines, Gent, Belgium  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n53 p537-48  
Rept. No. 53/74 ; 1974 ; 14p 2refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 403

# **INDUCTION RAMMING A MOTORED HIGH-SPEED FOUR-STROKE RECIPROCATING ENGINE--INFLUENCE OF INLET PORT PRESSURE WAVES ON VOLUMETRIC EFFICIENCY**

Calculation methods, and the results obtained from a computer program written for studying induction ramming in high-speed reciprocating engines is described. The calculation uses the method of characteristics for analyzing the pressure fluctuations in the intake pipe. Calculated airflows are compared with results obtained experimentally from a motor air-cooled four-stroke motorcycle engine. Comparison shows: using theoretical methods it is possible to predict with reasonable accuracy the volumetric efficiency of a motored high-speed reciprocating single-cylinder engine over a wide speed range; the undulatory character of the volumetric efficiency/speed curves of single-cylinder engines fitted with plain intake pipes results from two separate pressure wave effects influencing airflow during induction. These are: piston movements generating a rarefaction wave in the intake pipe, which travels to the pipe entry and is reflected to the port as a compression wave which can enhance airflow before inlet valve closes (i.v.c.); and after i.v.c., the same compression wave initiates a residual wave that persists well into the following intake period. The last two findings concluded that: peaks in the induction performance occur when a trough in the residual wave in the inlet pipe arrives at the open inlet valve when the piston speed is greatest; and the airflow into an engine, even through simple straight pipework, is most complex in nature and this prevents the formulation of simple methods of predicting ramming performance.

by T. G. Prosser  
Welsh Education Office, Dept. of Education and Science, England  
Publ: Institution of Mechanical Engineers, Proceedings, London, 1974 v188 n49 p577-84  
Rept. No. 49/74 ; 1974 ; 10p 20refs  
Availability: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, England

HS-017 404

# **ALCOHOL RELATED FATAL MOTOR VEHICLE TRAFFIC ACCIDENT STUDY. MICHIGAN. JANUARY--DECEMBER 1974**

Alcohol related fatal motor vehicle traffic accidents were studied in Michigan. The data for this study were based on investigations made of all 1651 fatal motor vehicle accidents within Michigan during the year 1974. It is reported that 47.9% (791) of the fatal traffic accidents were alcohol related, claim-



ing 47.7% (895) of the lives lost in traffic accidents. A total of 2,418 drivers were involved in fatal traffic accidents, of which 33.7% (817) had been drinking. Drivers under the age of 24 accounted for 41.6% of all had been drinking drivers in fatal accidents. March was the peak month for alcohol related fatal accidents; Fridays, Saturdays and Sundays accounted for 60.3% of the had been drinking fatal accidents, and 51.1% of the total fatal accidents; and 38.6% of the total alcohol related fatal accidents which occurred between the hours of 9 pm and 3 am. It was found that alcohol compounded the possibility of traffic accidents, and was the catalyst in most fatal accidents in the study. Drivers under 24 who had been drinking were found to have been drinking less than their older counterparts, but were more likely to be involved in accidents when they were drinking. It was found that young drivers seemed to undertake the learning processes of drinking and driving at about the same time. It is recommended that a continuing specialized traffic training session program to identify the drinking driver, provide breathalyzer training, and accident reconstruction seminars, could provide information for developing public awareness.

Michigan Dept. of State Police, Traffic Analysis Sec., Mich.  
1975 ; 21p  
Availability: Corporate author

HS-017 405

### **CHARACTERISTICS OF DISABLED VEHICLES ON ENGLAND'S YORKSHIRE AND LANCASHIRE MOTORWAYS [HIGHWAYS]**

An analysis was made of some of the fundamental aspects of disabled vehicles on limited access highways. It was found that only a small difference existed between the rate of disabled vehicles on Yorkshire highways where a high proportion of the flow consisted of business and commercial traffic and the rate of disabled vehicles on Lancashire highways where a high proportion of the flow was recreational. An analysis of the records of calls reporting breakdowns received from the emergency telephone system were examined, and hourly, weekly and monthly patterns of disablement were determined. An attempt to determine the age of disabled vehicles, the causes of disablement, and the effect of weather on breakdown rate was also made. Mechanical-electrical problems and lack of fuel were found to be significant factors in vehicle disablement. Climatic conditions, as measured by ambient temperature, were found not to have any significant effect on vehicle disablement. The age of the vehicles, assumed to be the date of first registration of the vehicle, offered little in the way of conclusions, except that vehicles reported as being disabled during the weekend periods in Lancashire were older than those reported disabled in Yorkshire. The average proportion of disablements occurring on any given day showed the highest percentage on Friday, with peak disablement hours being between 10-11 am, and 5-6 pm. In the early part of the summer vacation period more disablements occurred on Saturdays than on Sundays, mainly because of higher Saturday traffic volumes.

by R. J. Salter; K. S. R. Jadaan  
Publ: Transportation Research Record n536 p19-26 (1975)  
1975 ; 2refs  
Sponsored by the Com. on Motorist Services.  
Availability: See publication

HS-017 406

### **AID TO DISABLED MOTORISTS: RESPONSIVE ELECTRONIC VEHICULAR INSTRUMENTATION SYSTEM**

The advent of low-cost, highly reliable, integrated circuits has made the design and implementation of an electronic system for aiding disabled motorists feasible. A responsive electronic vehicular instrumentation system (REVIS) that detects all highway incidents independent of traffic-flow rate was analyzed on a cost-benefit scale. Major benefits which were found in REVIS were a substantial reduction in incident-detection time, particularly on rural, limited-access highways. It was determined that an average of 1,650 incidents occurs per year for a 75-mile length of rural highway. If the mean time between highway patrol vehicles on a fixed schedule is 2 hours on that stretch of highway, and the average distance to the nearest towtruck or aid vehicle is 50 miles, a reduction in total average wait of 1 hour can be achieved by REVIS, due to its ability to track each vehicle microscopically. Considering that the cost of police patrol service, whose primary function is incident detection is at least \$90,000 per year per vehicle, the cost and functional effectiveness of patrol vehicles may be increased by assigning the incident-detection task to REVIS. By suitably modifying the system and adding peripheral equipment, it was found that REVIS can be used as a research aid in determining patterns of driving behavior that create a high probability for accidents, such as investigation of spatially sampled speed and lane position records of vehicles involved in accidents. The total cost of a REVIS instrumented road, including operator, maintenance and capital cost, prorated over 5 years is found to be less than the total cost for a conventional highway patrol over the same road.

by Joseph S. Nadan; Richard Wiener  
Publ: Transportation Research Record n536 p31-47 (1975)  
1975 ; 31refs  
Sponsored by the Com. on Communications.  
Availability: See publication

HS-017 407

### **HIGHWAY DESIGN AND OPERATIONAL PRACTICES RELATED TO HIGHWAY SAFETY. 2ND. ED.**

Ideas and practices throughout the field of highway engineering are brought together. The following topics are covered: design considerations for access control, bridges, railroad crossings, skid resistant pavements, pedestrian, bicycle, and wildlife crossings; interchange patterns, spacing, ramps, frontage roads, lane drops, gore areas, and route continuity; roadside design, including roadside slopes, the "forgiving roadside", medians, and median crossovers; roadside hazards, such as signs and sign supports, protective barriers, guardrails, median barriers, impact attenuators and highway lighting; traffic operations for slow-moving vehicles, fog, nighttime driving, signing, pavement markings, highway location reference systems, surveillance and ramp control, wrong-way control, rest areas, emergency communications, police traffic supervision, and motorist's services signing; construction and maintenance operations for planned traffic management, traffic control, and work area and detour problems; and programming for improvement of existing highways, including spot safety,

February 29, 1976

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blanket safety, maintenance personnel, and evaluation of safety improvements.

American Assoc. of State Hwy. and Transportation Officials, 341 National Press Bldg., Washington, D.C. 20045  
1974 ; 94p 6refs  
Supplements two earlier reports: "A Policy on Design of Urban Highways and Arterial Streets" (1973) and "A Policy on Geometric Design of Rural Highways (1965).  
Availability: Corporate author

sites, during day and night; and for several sites, illumination appeared to improve nighttime performance.

by Nick J. Rackoff; Thomas H. Rockwell  
Ohio State Univ., Driving Res. Lab., Columbus, Ohio 43210  
Rept. No. Ohio-DOT-10-74 ; 1974 ; 109p 35refs  
Conducted in cooperation with the Federal Hwy. Administration.  
Availability: Corporate author

HS-017 408

#### **OPTIMAL HIGHWAY SAFETY IMPROVEMENT INVESTMENTS BY DYNAMIC PROGRAMMING**

A dynamic programming procedure is developed selecting the optional combination of safety improvement projects for a given budget. Sixty-one projects (general, curve and intersection improvements), each with one or more alternatives, were evaluated. The input consisted of the designated budget for the safety improvement program, the improvement cost, and the benefits derived from each improvement. The accuracy and reliability of dynamic programming is dependent upon the accuracy of benefits and costs used as input. In a comparison with benefit-cost analyses, it was shown that dynamic programming can yield a higher return for a given budget. An optional allocation of funds will always be obtained if the individual project costs are multiples of the increment used in dynamic programming. The applicability of dynamic programming to budget allocation in transportation planning is practically unlimited. In addition to the various highway programs, dynamic programming can be used to optimize investments for entire transportation departments.

by J. G. Pigman; K. R. Agent; J. G. Mayes; C. V. Zegeer  
Kentucky Dept. of Transportation, Div. of Res., 533 South Limestone, Lexington, Ky. 40508.  
Rept. No. RR-398 ; 1974 ; 52p 14refs  
Availability: Corporate author

HS-017 410

#### **A SUMMARY OF OPPORTUNITIES TO CONSERVE TRANSPORTATION ENERGY. FINAL REPORT**

Near term opportunities for energy conservation in passenger and freight transportation are surveyed. The 1972 transportation energy flows and modal efficiencies are characterized. A total of 35 possible conservation measures are discussed and ranked for effectiveness. Their potential fuel savings are projected for 1980 and 1990. The most important measures: costs, timing constraints, and side effects are reviewed. There are 5 approaches to conservation of direct transportation energy: improvement of efficiency of future vehicles through design and technology changes; increased load factors; operation changes such as reduced speed and improved maintenance; service reductions; and diversion of passengers and goods to more efficient modes. Highway vehicle efficiency improvements are found to be the most important option for the 1980's due to the fact that motor vehicles now consume the major share of transport energy; efficiency gains have relatively little impact on the quality of the transportation service; and implementation of efficiency improvements will reduce total cost of transport. Load factor improvements are the second most important class of options, and operational improvements, such as lower speed limits, were found to be capable of generating savings of up to 5% of the total direct transportation energy.

by John Pollard; David Hiatt; David Rubin  
Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142  
Rept. No. DOT-TSC-OST-75-22 ; 1975 ; 106p 49refs  
Rept. for Jan 1973-Jun 1975.  
Availability: NTIS

HS-017 409

#### **EVALUATION OF ILLUMINATION DESIGNS FOR ACCIDENT REDUCTION AT HIGH NIGHTTIME ACCIDENT HIGHWAY SITES. INTERIM REPORT**

A quantitative technique, based upon driver visual search performance and driver control performance was developed to evaluate the potential accident-reduction effectiveness of illumination designs. Six subject drivers drove an instrumented vehicle through nine intersections with known night accident rates, during both day and night. Drivers' visual search patterns (fixation times, distribution of fixations in the road scene, visual spatial and temporal activity) and driving control measures were recorded and analyzed. Results indicate different patterns of driver behavior at high and low accident-rate sites; at intersections with and without illumination; and at sites with high night-accident and low night-accident rates. The results of the analyses indicate that the visual search measures and control measures proved sensitive to conditions compared under the three conditions, as well as task instruction (straight driving versus left turn); daytime performance was superior to nighttime; performance at low night-accident-rate sites appeared superior to performance at high night-accident-rate

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#### **CITY OF PHILADELPHIA. TRAFFIC ACCIDENT FACTS, 1974**

An analysis of 1974 motor vehicle accident records for Philadelphia, Pennsylvania is presented. The number of reported accidents showed a decrease of 4,205 in 1974, directly in line with the national trend. Police records of 62,345 accidents are analyzed. Statistics for the following accident factors are included: accident, death, and injury summary by month; comparative accident summary (1974 versus 1973); type of accidents (collision with what, ran off roadway, overturn on the road, other non-collision); accidents by the day of the week; accidents by the time of day; comparison of accidents versus traffic volumes; persons killed or injured by age groups and sex; pedestrian death and injury rates by age groups; pedestrian movement action by age group and by those killed and injured; hazardous road conditions; residence of drivers; locality of accidents; drivers by age groups and sex; principal accident violations; analysis of vehicle movement (for double vehicle, single vehicle and pedestrian ac-

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cidents); types of vehicles involved in accidents; light conditions; accidents and vehicle registrations; and traffic accident trends, 1950-1974. Traffic engineering, enforcement, and safety education are discussed as accident prevention activities. It was found that 58% of all Philadelphia accidents occurred between intersections and along straight stretches of streets, while only 41% occurred at intersections and less than 1% along curves. Driver action was responsible for over 93% of all accidents. The failure of drivers to recognize and avoid potential driving hazards is considered the most prevalent cause of motor vehicle accidents and the need for increased traffic safety education for all residents is stressed.

Pennsylvania Dept. of Streets, Traffic Engineering Div.  
Philadelphia, Pa.  
1974 ; 39p

On cover: Traffic Accidents 1974, Philadelphia.  
Availability: Corporate author

HS-017 412

### CHILD PEDESTRIAN INJURIES

The importance of pedestrian accidents as a source of injury to children is discussed. A current at-the-scene study (begun in 1973 in Birmingham, England) is described in which researchers are informed of pedestrian accidents by the police. One researcher interviews the driver and witnesses while the other records the location and nature of the pedestrian contacts with the vehicle, the location of skid marks and debris, and the final position of the vehicle. Photographs are also made of the vehicle and the scene. Later, injury information is obtained from the hospital involved and injury photographs may be taken. Questionnaires are sent to the witnesses not interviewed at the scene and to those pedestrians not interviewed in hospitals to obtain further information, particularly about the height and weight of the pedestrian. Results of the first 100 accidents are presented with results from a previous at-the-scene study (1969). A total of 184 accidents involving 185 vehicles and 190 pedestrians (177 single-pedestrian-single-vehicle, 6 double-pedestrian-single vehicle, and one single-pedestrian-double-vehicle accident) are considered. Statistics on the following accident characteristics are included: type of vehicles involved; location of first pedestrian contact with vehicle (excluding two-wheeled vehicles); impact speed distribution; injury severity by impact speed, age of pedestrian and cause of injury (frontal impacts); location and severity of injury by pedestrian age and cause of injury (frontal impacts); cumulative distribution of age of pedestrian casualties for various severities of injury for 1971; height of lower edge of knee (sole to popliteus) by age; width of knee by height of lower edge of knee; cumulative distributions of the heights of the top and bottom of the knee for serious and fatal pedestrian casualties (1971); and percentage of involved population (serious and fatal injury) sustaining a direct knee contact from a bumper of given dimensions. It was found that: the majority of pedestrians (78%) were contacted by the front or front corners of the striking vehicles; cars were the most frequently (77%) involved vehicles; children appeared to sustain less severe injuries than adults at comparable impact speeds; and a bumper height of

18-20 inches results in the maximum number of pedestrians sustaining a direct knee contact from the bumper.

by S. J. Ashton; H. R. M. Hayes; G. M. Mackay  
University of Birmingham, Dept. of Transportation and  
Environmental Planning, England  
Publ: Biomechanics of Trauma in Children, Proceedings of the  
International Meeting, 1974, p159-170  
1974 ; 13p 9refs  
Meeting held in Lyon, France, 17-19 Sep 1974. Sponsored by  
the International Res. Com. on Biokinetics of Impact.  
Availability: Reference copy only

HS-017 413

### INJURY PATTERNS IN MOTORCYCLE COLLISIONS

This report describes the incidence, nature and severity of trauma for injured and medically treated motorcyclists in Sacramento County, California in 1970. Using official reports from police, hospital admissions and emergency room medical records, 1273 persons with a confirmed medically treated motorcycle injury were identified. Since less than 39% of all injured motorcyclists were identified in this study by use of official police reports only, statistics which rely solely on these reports greatly underestimate the frequency of motorcycle collision injuries in the community. The annual injuries incidence was 2.0 per 1,000 population, with peak incidences rate for male drivers 18 years of age. Slightly more than 4% of all registered motorcycles were involved in an injury-producing collision in a single year. Almost 45% of injured motorcyclists suffered a serious injury, with injuries to the musculoskeletal system in the form of fractures being the most common. The average length of hospital stay was 12 days, and three-fourths of those injured indicated one or more days of disability.

by Walter F. Drysdale; Jess F. Kraus; Charles E. Franti;  
Richard S. Riggins  
Publ: Journal of Trauma v15 n2 p99-115 (Feb 1975)  
1975 ; 22refs

Supported in part by the Insurance Inst. for Hwy. Safety and  
the Dept. of Community Health of the Univ. of California  
School of Medicine.  
Availability: See publication; Jess F. Kraus, Dept. of  
Community Health, Univ. of California at Davis, School of  
Medicine, Davis Calif. 95616

HS-017 414

### DEFENSE AND SETTLEMENT OF CLAIMS FOR SKIDDING ACCIDENTS

Statutes of limitation of 43 states and the District of Columbia may bar a claim against a highway design engineer. If the design engineer is not protected from claims of third parties by state statute, he or she may have no liability if the design and the structure were completed and accepted by the owner. In determining whether the design engineer may be liable to claims of third parties, (the travelling public), 5 questions are to be evaluated: Did the design engineer owe a duty to the public; was the duty continuing in nature; was there a breach of the duty; did the breach of the duty constitute a "public nuisance"; and did the breach of duty cause or materially contribute to the events giving rise to the claims? Should a claim be made against a design engineer as the result of a skidding accident, drawings, records and files are the most important defense tools. He or she should always retain the owner's instructions, his or her calculations, and the research into design

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criteria on each project because this material is the record that will determine whether he or she will be exposed to liability.

by William B. Somerville  
Publ: Transportation Research Record n523 p25-30 (1975)  
1975 ; 2refs  
Sponsored by the Legal Resources Group Council and Group  
2 Council.  
Availability: See publication

noise (method of estimating); and the effect of highway noise barriers.

by W. H. Close; J. E. Wesler  
Publ: Transportation Research Record SR-152 p14-33 (1975)  
1975 ; 6refs  
Availability: See publication

HS-017 415

HS-017 417

### RELATIONSHIP BETWEEN TIRE INFLATION PRESSURE AND MEAN TIRE CONTACT PRESSURE

### EFFECT OF MOTOR VEHICLE REGULATIONS ON HIGHWAY NOISE LEVELS

The relationship between tire inflation pressure and tire contact pressure was made, using 6 highway tires, of the type found on heavy commercial vehicles in South Africa, ranging in size from 7.50-15 x 10 to 11.00-22 x 14. The tires were mounted in a Baldwin press and left for 24 hours to attain equilibrium at a given temperature. The tire was then loaded to the desired load and a print of the contact area was made. It was found that: under normal conditions of wheel load and inflation pressure the average contact pressure between the tire and the road will be less than the tire inflation pressure; tire contact pressure is a function of both inflation pressure and wheel load and is a constant depending on the type of tire; and the relationship between tire inflation pressure and contact pressure lies within a narrow band for the tires tested. For the combination of wheel load and tire pressures recommended by the manufacturer, an average relationship of contact pressure in kilopascals equals 0.61 inflation pressure plus 145. A 100% increase in load normally is associated with a 30 to 40 percent increase in contact pressure. At constant load, a 100% increase in inflation pressure will be associated with an average increase of 30% in contact pressure. If both wheel load and tire inflation pressure change in accordance with the tire manufacturer's recommendations, a change in inflation pressure will be associated with a 60% change in contact pressure.

The change in noise levels resulting from the introduction and enforcement of noise regulations is examined to place the effectiveness of individual motor vehicle noise control into perspective. Highway and vehicle noise descriptors (the noise level that is exceeded 10% of the time, and a calculation of the average intensity of the noise signal over a period of time) are discussed. The following effects are considered: hypothetical noise levels for a single vehicle class; the effect of noise regulations on vehicle noise levels; decrease in average noise intensity with time for various new-vehicle standards; the effect on average noise intensity of various operating limits and degrees of compliance; overall noise levels of trucks operating in greater than 35 mph speed zones after the introduction of regulations; and the effect on highway noise level of reducing truck noise. It is concluded that: motor vehicle regulations applied only to new vehicles form a rather long-term solution for highway noise reduction; motor vehicle regulations applied to operating vehicles have an immediate impact on vehicle and highway noise levels; the optimum reduction of vehicle noise levels requires a careful combination of both types of regulations; and the largest reduction in vehicle noise levels results from the application of an operational type of regulation on a previously unregulated population of vehicles (further reduction becomes progressively more difficult and costly).

by D. J. van Vuuren  
Publ: Transportation Research Record n523 p76-87 (1975)  
1975 ; 11refs  
Sponsored by the Com. on Surface Properties-Vehicle Interaction.  
Availability: See publication

by Ben H. Sharp  
Publ: Transportation Research Record SR-152 p34-43 (1975)  
1975 ; 7refs  
Availability: See publication

HS-017 416

HS-017 418

### VEHICLE NOISE SOURCES AND NOISE-SUPPRESSION POTENTIAL

### NOISE CONTROL STRATEGIES FOR NEW AND IN-USE TRUCKS

Various statistics and other information on vehicle noise and noise sources are discussed. The following areas of concern are considered: percentage of people annoyed by and sources of residential noise; population and use of mobile noise sources in the United States (U.S.); speed trends on main rural highways by vehicle type; truck noise (trucks in use by age group, truck noise sources, diesel truck noise sources, effect of speed, wear, axle loading, and road surface on truck tire noise, truck intake and exhaust noise, truck cooling system noise, truck engine noise); passenger car noise (tires and engines); motorcycle noise; noise certification levels; sound propagation factors; atmospheric attenuation; general traffic

A comprehensive system for control of in-use truck noise, coupled with periodic inspection, highway surveillance, and use of truck weighing stations is needed to control the noise emissions of trucks. The effects of this system on a number of trucks within various noise categories are examined. The associated analytical techniques are outlined, and the method is applied to an idealization of a practical situation. The truck population is divided into mutually exclusive classes, such as: trucks in the truck population at the start of a regulation; those manufactured after the first stage of the regulation; and those manufactured after the second stage of the regulation. However, the division is not limited to these categories and can be applied to a wide variety of cases, including variable truck manufacturing rates and variable truck retirement rates. The technique has been applied to an approximate model of the interstate motor carrier regulation and the proposed new-truck regulation and indicates that the population of trucks in use when the new-truck regulation is promulgated will dominate the total truck population for a long time afterwards.

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Further work using variable manufacturing and retirement rates, as well as a more refined estimate of the initial truck population should be undertaken to supplement the work reported in this first installment.

by C. T. Molloy  
Publ: Transportation Research Record SR-152 p72-6 (1975)  
1975

Availability: See publication

HS-017 419

# **TIMETABLE FOR VEHICLE NOISE REDUCTION**

The present and proposed California schedules of reduced noise levels for new passenger cars, motorcycles, trucks and buses are presented. The recommendations of the advisory committee appointed to expand noise regulations and develop new time-tables are discussed for the following: new-vehicle noise limits; highway noise limits (for in-use vehicles); heavy truck classification; new urban transit bus limits; certified tires; certified mufflers; inspection of muffler retail outlets; muffler certification stations; dynamometer testing; highway measurement sites; increase in noise teams (for enforcement purposes); local noise enforcement; and tests for maximum noise. The committee's report had a substantial influence on new noise legislation for motor vehicles.

by Warren M. Heath  
Publ: Transportation Research Record SR-152 p46-54 (1975)  
1975 ; 4refs

Availability: See publication

HS-017 420

# **EVALUATION OF THE EFFECTS OF MOTOR VEHICLE NOISE REGULATIONS ON POPULATION**

A conceptual method for quantifying the effects of a change in environmental noise on public health and welfare is presented, and, as an example of the method, a first approximation to quantifying the impact of motor vehicle noise regulations is given. Emphasis is placed on the average response of groups of people to noise, where average response is a combination of factors such as speech interference, sleep interference, desire for a quiet environment, and the ability to use TV, telephone, and radio satisfactorily. The measure of the response is expressed in terms of the magnitude of the population that would be expected to express, in a social survey, a high degree of annoyance as a result of a specific noise exposure level. The model application makes the following assumptions: traffic speed is 55 mph; tire noise has been reduced to 77 decibels; 6-lane highway with peak hour traffic flow of 7,200 vehicles per hour; vehicle mix is 10% trucks, 90% automobiles; population living within one mile of an urban freeway is evenly distributed at about 5,000 people per square mile; and the typical house is on a 100x50 foot lot with the closest one being 70 feet from traffic lanes. The following results are tabulated: the impact produced by traffic noise; reduction in day-night sound level relative to 1974 decibel regulations; determination of change in impact with 2.4 decibel reduction in day-night sound level on highways relative to 1974 levels; and the number of people experiencing noise exposure from vehicular traffic at a fractional impact equal to unity.

by Simone L. Yaniv  
Publ: Transportation Research Record SR-152 p77-84 (1975)  
1975 ; 9refs

Availability: See publication

HSL 76-02

HS-017 421

# **A PROCEDURE FOR CALCULATING THE CHARACTERISTICS OF RADIAL DEFORMATION OF BELTED TIRES (EIN VERFAHREN ZUR BERECHNUNG DER RADIALVERFORMUNGSSCHARAKTERISTIKEN DES GURTELREIFENS)**

The basic concept that the air pressure is the preponderant component of elasticity is the assumption of this report. It is possible to put together a simple relationship between the stress and the reduction of the volume after deformation by using an equation involving the energy of the stress causing deformation and the energy which the air content of the tire absorbs. The description of the procedures for calculating the volume in the case of belted tires forms the essential portion of the report. In conclusion, a comparison is given between what has been calculated and the measured characteristics of deformation and also results of measurements of pressure in deformed belted tires. In both cases, the portion of the total energy of the deformed belted tire furnished by the air is essentially smaller than in the case of radial deformation. Therefore, the procedure for calculating the corresponding force cannot be transferred over to these cases directly.

by F. Koutny  
Research Inst. of Rubber and Plastics Technology, 764 22  
Gottwaldov, Czechoslovakia  
Rept. No. LS-49848 ; 1974? ; 59p 14refs

Text also in German.

Availability: Reference copy only

HS-017 422

# **A MODEL AND PREDICTIVE SCALE OF PASSENGER RIDE DISCOMFORT**

A model to define the interrelationship of the various factors (vibratory and nonvibratory) important to passenger comfort, in realistic transport vehicle vibration environments was developed as part of a ride quality program at NASA-Langley Research Center. The model, in addition to representing a mechanism for obtaining consistent information on the effects of vibratory and nonvibratory factors on passenger discomfort, represents: a framework for the investigation of comfort within diverse transportation vehicles; a mechanism for the development of a scale of comfort; a mechanism through which design criteria can be obtained for improving the rideability of current and future transportation vehicles; and a tool for obtaining information for the maximization of passenger ride quality, based upon sociological and psychological information. The application of the model is based upon the computational steps necessary for derivation of the comfort scale. The emphasis within the scale is upon the summation of comfort units; the summation being obtained through the use of appropriately determined weighting factors, both within and between axis. The proposed comprehensive model contains several major concepts: the establishment of equal comfort curves for all axis; the establishment of discomfort units as a function of frequency and amplitude within an axis; a determination of the empirical laws for summation of discomfort within an axis based on masking within an axis; a determination of the empirical laws for summation of discomfort units between axes based on between axis masking; the derivation of a scale of discomfort; the correction of the comfort scale



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for temporal variations in ride spectra characteristics; and the correction of the comfort scale for nonvibratory factors.

by Thomas K. Dempsey  
NASA-Langley Res. Center, Hampton, Va. 23665  
Rept. No. NASA-TM-X-72623 ; 1974 ; 30p 40refs  
Availability: NTIS \$3.75

HS-017 423

### **DRIVER EDUCATION IN PUBLIC AND NON-PUBLIC HIGH SCHOOLS. SUMMARY REPORT**

This summary report on the Kentucky driver education program in public and non public and non public schools covers a span of 8 years. A survey analysis of the state by region, by school district, of student data, such as year in school and age, by teaching staff, of the number of cars by source and insurance, and of staff responses by the categories of knowledge, skill and attitudes, were helpful in evaluating and providing strong reinforcement of the operational phases of the program. The composite item count strongly favors: attitudes; knowledge of the car, roadway and driving conditions; and skills, or manipulative operations. Region by region base data are presented, as well as a copy of the annual questionnaire of the State of Kentucky which is used as a help in analyzing driver education programs.

Kentucky Dept. of Education, Div. of Prog. Devel., Frankfort, Ky.  
1975 ; 108 p refs  
Financed and published under subelement number 304-74-004-0, task number 1 of the FY 74 Kentucky Annual Hwy. Safety Work Prog. On cover: "Report of the Kentucky Driver Education Program".  
Availability: Corporate author

HS-017 424

### **NOT FOR BEGINNERS. HOW GOOD DRIVERS DRIVE BETTER**

Ideas, descriptions, and advice are given concerning the following driving situations: cornering (oversteer and understeer); slippery roads; emergency situations (tire blow-out, loss of brakes, broken windshield); low visibility; long distance driving; economy driving; and towing. Some techniques normally used by race drivers but perhaps useful to everyday driving are discussed. These include: double de-clutching; heel-and-toe control of accelerator and brake; left-foot braking; crossing hands on the steering wheel; changing gear without the clutch; and fast cornering using the hand brake. The opinions of professional racing drivers Emerson Fittipaldi, Bernard Unett, Brian Culcheth, and Mario Andretti on these matters are also included.

Publ: Autocar v143 n4108 p20-5 (Aug 1975)  
1975  
Availability: See publication

HS-017 425

### **SUPPLEMENTARY LICENSING: AN EVALUATION**

The Greater London Council published the results of a study into supplementary licensing as a proposed method of traffic restraint requiring drivers of certain vehicles (commercial vehi-

cles and automobiles belonging to non-residents of the city) to purchase special licenses in order to use their vehicles at specified times (morning and evening peaks) in designated areas. A number of alternative schemes on traffic patterns, on the environment and on the social and commercial framework of the city were also reviewed. Areas controlled were the central and inner areas of the Greater London metropolitan area. It was found that not all criteria are satisfied by the same alternative. Greater environmental improvement would be gained by adding Inner Area peak control, but on most other considerations Central Area control would be preferable. Peak period control in the Central Area would involve fewer staffing problems than all-day control, but would provide little environmental relief. The study concluded that all-day control in the Central Area would be the most efficient form of control, unless environmental gains from the extension of control to the Inner Area in the peak could be shown to outweigh the reduction in other benefits and the increased staffing problem.

by A. D. May  
Publ: Traffic Engineering and Control v16 n4 p162-7 (Apr 1975)  
1975 ; 13refs  
Availability: See publication

HS-801 182

### **MULTIDISCIPLINARY ACCIDENT INVESTIGATION. FINAL REPORT. VOL. 3, SPECIAL STUDIES**

A study was made of 5,481 traffic accidents in the San Antonio/Bexar County area from December 1, 1972 to May 31, 1973 in which 10,371 vehicles and 15,170 occupants were involved. Principal objectives were to compare vehicle damage and occupant injury codes and indices currently in use, and analyze significant relationships concerning vehicles and occupants. The volume of data necessitated application of electronic data processing and computer analysis. The methodology employed is described. Results are categorized into two broad groups--comparison between accident measures and analysis of variables. Comments are made on each of the damage and injury measures and upon interrelationships between vehicle and occupant properties. The Police Injury Code proved to be of little value as an injury severity measure. Distinctive comparisons can be made in the vehicle damage measures and the Traffic Accident Data Scale seems to be applicable under controlled conditions to nearly 90% of accident types. Variance in side impact damage is less for three types of vehicles examined, than for front and top damage. Average operator age was shown to increase with vehicle size. Seat-belt usage increased with occupant age. The Vehicle Deformation Index provided a quantification of collision-induced damage which is more consistent in its application than the Traffic Accident Data scale.

Southwest Res. Inst., 8500 Culebra Rd., San Antonio, Tex. 78284  
Contract DOT-HS-024-1-115; Ref: FH-11-7219  
Rept. No. SWRI-11-3075-Vol-3 ; 1974 ; 114p  
Rept. for 1 Feb 1971-18 Mar 1974. See also vol. 1 (HS-801 180), vol. 2 (HS-801 181), and vol. 4 (HS-801 183).  
Availability: NTIS

HS-801 472

HS-801 472

### **INJURY RATE AS A FUNCTION OF TRUCK WEIGHTS IN CAR-TRUCK ACCIDENTS**

The preliminary results of an analysis of 13,177 car-truck accidents in 1973, which involved either injury or property damage in excess of \$2,000 are presented. The relationship between truck weight and truck occupant injuries, nontruck occupant injuries, and nontruck occupant deaths was examined. It was found that the fatality rate for nontruck (car) occupants was directly proportional to the weight of the truck; while the injury and fatality rate for truck occupants became constant for trucks weighing more than 20,000 pounds.

by Thomas N. Herzog  
National Hwy. Traffic Safety Administration, Mathematical Analysis Div.  
Rept. No. NHTSA-TN-N43-31-7 ; 1975 ; 14p 1ref  
Availability: NHTSA

HS-801 541

### **VEHICLE EXTERIORS AND PEDESTRIAN INJURY PREVENTION. VOL. 1. SUMMARY REPORT. FINAL REPORT**

by Hayes E. Ross, Jr.; Ronald D. Young; Adil M. Mayyasi; Thomas A. Krouskop  
Texas A and M Univ., Texas A and M Res. Foundation, College Station, Tex. 77843  
Contract DOT-HS-065-1-217  
Rept. No. RF-814-1-Vol-1; PB-242 065 ; 1975 ; 24p 4refs  
Rept. Jul 1971-Jul 1973. For abstract, see vols. 2-5, HS-801 542-801 544 and 801 547.  
Availability: NTIS

HS-801 543

### **VEHICLE EXTERIORS AND PEDESTRIAN INJURY PREVENTION. VOL 3. THE TEXAS A AND M UNIVERSITY INJURY SEVERITY INDEX. FINAL REPORT**

This study has been directed toward developing an analytical model which relates the kinematic variables that describe a collision between a vehicle and a pedestrian to the level of injury or the injury severity index number that the pedestrian sustains. The resulting injury index accomplishes this goal and also accounts for the effects of multiple injuries on the general state of the victim. The method, to quantify the severity of injuries utilizes medical descriptions from accident records, or victim kinematics, as determined from numerical or physical simulation. Based on the results of this method the following conclusions were formulated: strain energy density provides a meaningful criterion for establishing tissue failure thresholds due to impact injuries; results of this study injury threshold index compares with the thresholds predicted by other criteria, in the limited number of cases studied; and the injury severity ranking index that was developed in this project provides consistent methodology that enables the level of injury to be predicted by either knowing the kinematic variables that describe a collision or by clinically evaluating the victim's condition

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and using the observed injuries to rank the victim's overall condition.

by Thomas A. Krouskop; Paul H. Newell, Jr.; Albert E. Swarts  
Texas A and M Univ., Texas A and M Res. Foundation, College Station, Tex. 77843  
Contract DOT-HS-065-1-217  
Rept. No. RF-814-1-Vol-3; PB-242 067 ; 1975 ; 37p 62refs  
Rept. for Jul 1971-Aug 1972. See also vol. 1, HS-801 541 (Summary Report); vol. 2, HS-801 542, and vols. 4 and 5, HS-801 544 and HS-801 547.  
Availability: NTIS

HS-801 644

### **ASSESSMENT OF PRESENT STATE OF KNOWLEDGE FOR UNSAFE TARGET DRIVING BEHAVIORS AND SAFE DRIVING CONFORMANCE COUNTERMEASURES APPROACHES. TASK 2 REPORT**

The present state of knowledge relating to the development of a safe driving conformance program is assessed. The program is divided into two areas of information: target driving behaviors, and countermeasures. The study first indicated the information requirements in both of these areas. Information requirements for the selection of target driving behavior include the following: identifying specific driving behavior which results in substantial numbers of traffic accidents; establishing which of these behaviors are within the control of the normal licensed driver; identifying the situational factors, such as location and weather conditions, in which these driving behaviors most frequently result in accidents; and identifying which groups of drivers commit which specific unsafe target driving behaviors. A literature review based on 257 sources was conducted to determine how much is known. The information available was compared with the requirements to specify areas of deficit knowledge. Mechanical systems, regulatory traffic safety laws, communications, agencies from the government to private level, and detection systems, such as mobile police patrols and automated detection devices, are suggested as tentative methods of detecting and regulating unsafe driving behaviors.

by Robert L. Hiett; Jay W. Worrall; Gary L. Brown; Donald L. Witten  
Human Sciences Res., Inc., Westgate Res. Park, 7710 Old Springhouse Rd., McLean, Va. 22101  
Contract DOT-HS-4-00988  
Rept. No. HSR-RR-75/1-We ; 1975 ; 269p refs  
Rept. for 28 Jun 1974-30 Jun 1975.  
Availability: NTIS

HS-801 650

### **MOTOR VEHICLE SAFETY DEFECT RECALL CAMPAIGNS REPORTED TO THE NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION BY DOMESTIC AND FOREIGN VEHICLE MANUFACTURERS, APRIL 1, 1975 TO JUNE 30, 1975**

This tabulation of safety defect recall campaigns includes the make and model, model year, description of the defect requiring manufacturer's corrective action, number of vehicles recalled, date of notification, and identification number. Automobiles, trailers, motor homes, boat trailers, trucks, semi-

trailers, buses, motorcycles, anti-lock systems, wheels, tires, disc brake assembly, shock absorbers, locks, fairings, and road lamps are included. The status of domestic and foreign campaigns completed as of June 30, 1975 are also given.

National Hwy. Traffic Safety Administration, Washington, D.C. 20590  
1975 ; 43p  
Availability: GPO

HS-801 660

#### **STUDY OF THE DETECTABILITY OF CONTROLLED SUBSTANCES ON BREATH. FINAL REPORT**

One of the objectives of this study was to develop technology which would permit analysis and detection of quantities of an active marijuana substance (delta 9-THC) on human breath. To accomplish this objective a high pressure liquid chromatography mass spectrometer technique was developed. With this technique delta 9-THC has been selectively and quantitatively identified on human breath following marijuana smoking. Also two different types of breath collecting apparatus were designed and evaluated during the study. Data obtained with each apparatus clearly demonstrated that each collection method had certain merits. With the polyethylene foam wafer device, delta 9-THC and a marijuana metabolite were concentrated from a subject's expired air stream. This particular device offers the ultimate in simplicity and portability. During one phase of the present study, samples were collected from the breaths of marijuana smokers and the polyethylene foam wafers were then either transported or mailed to a distant point for analysis. The earlier study provided additional information about the portability and mailability of the wafers since the wafers were not processed until 3 weeks after the breath collection. Results obtained were comparable to those wafers which were processed immediately after breath collection. Experiments with the ethanol breath tube demonstrated several apparent advantages over the polyethylene foam wafer. One advantage was the slightly increased amounts of delta 9-THC found. This increased level is most likely due to the high solubility of delta 9-THC in ethanol plus the very cold temperatures which condense water droplets carrying the cannabinoids from the lungs. Another advantage of the ethanol breath tube is that it appears to collect two additional metabolites. Data collection during the study clearly demonstrated that delta 9-THC on the breath will be exceedingly small after only two hours, and metabolites can remain and be detected in breath samples up to five days after marijuana smoking. The exact length of time this metabolite can be detected is not known. A combined analysis of delta 9-THC and the metabolite may give information about the amount of time which had elapsed between smoking and sampling.

by P. J. Bryant; J. L. Valentine; P. L. Gutshall; O. H. M. Gan; P. Driscoll  
University of Missouri, School of Pharmacy, Kansas City, Mo. 64108  
Contract DOT-TSC-389  
1975 ; 48p 11refs  
Rept. for 28 Jun 1974-28 Jun 1975. Supported in part by the National Inst. on Drug Abuse.  
Availability: NTIS

HS-801 661

#### **EVALUATION OF AN ADVANCED AUTOMOTIVE RESTRAINT SYSTEM USING HUMAN SUBJECTS. FINAL REPORT**

The Department of Transportation sponsored a research program at the Naval Air Development Center utilizing its Horizontal Accelerator facility to conduct dynamic tests on advance passive seat belt restraint systems using both anthropometric dummies and human volunteers. Phase 2 is described, in which subjects succeeded in tolerating exposure to simulated car crashes involving velocity changes of over 30 mph and peak accelerations of over 21 g's, when using a conventionally configured restraint system of advanced design, and applying techniques of body posturing and muscular tensing. The three belt restraint, containing energy absorbing fiber bundles was integrated with a padded, bucket, car seat. Although both subjects utilized head flexing, body muscular tensing, and leg bracing to withstand the applied forces, the specific manner in which each achieved this goal was somewhat different. It was found that: muscular tensing and proper body positioning enable trained volunteers to withstand the application of relatively high dynamic restraint and inertial loads with only minimal resulting discomfort; the incorporation of energy-absorbing fibers within the restraint belt appeared to mitigate the loads applied to the body, but the nature and extent of load attenuation by this means remains obscure; and the use of present state of the art anthropomorphic dummies to predict dynamic and kinematic effects of applied impulsive loads on human subjects is so limited, under the conditions of testing described in this report, that it serves only as a means of determining gross structural integrity of the restraint system.

by Edwin Hendler; Joseph O'Rourke; Leon Domzalski; Mark Katzeff; Marvin Schulman  
Naval Air Devel. Center, Crew Systems Dept., Warminster, Pa. 18974  
Contract DOT-HS-063-1-081-IA  
1975 ; 99p 11refs  
Availability: NTIS

HS-801 712

#### **COMFORT AND CONVENIENCE ANALYSIS OF ADVANCED RESTRAINT SYSTEMS. FINAL TECHNICAL REPORT**

Five restraint systems were evaluated in terms of comfort and convenience by 10 subjects. The systems were: an AMC Hornet with modified active restraint system; a Chevrolet Impala with two restraint system take-up reels; a Cadillac Seville with a single loop webbing system; an AMC Hornet with a fully passive restraint system and no lap belt; and an AMC Hornet with a semi-passive restraint system. Statistical analysis of particular questions and system comparisons (supplemented with subject and questionnaire comments) uncovered potential problems with individual system characteristics and provided overall system rankings. The standard lap and shoulder belt system of the Chevrolet Impala was found to be more acceptable than the advanced systems. Several aspects of the systems caused difficulties or confusion, but the single-loop "window shade" feature most frequently produced problems. The following observations were most often made: positioning of the latch plate was a problem for the two single retractor active systems; entering passive and semi-passive cars was generally easy; seat adjustment was difficult in the systems having fixed

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seat belt length after buckling; systems having the "window shade" feature were poor in the areas of fit, staying on the shoulder, and proper storage; the semi-passive Hornet produced the most chafing discomfort, and the passive Hornet scored poorly on interference with exit; the active Cadillac and the active Hornet scored poorly on emergency exit from driver's door; and subjects found it nearly impossible to make an opposite side exit through the webbing of the semi-passive Hornet and nearly so for the passive Hornet.

by David Breedon; Stephen Gordon  
National Hwy. Traffic Safety Administration, Safety Res.  
Lab., Washington, D.C. 20590  
1975 ; 59p  
Rept. for Jul 1975-Aug 1975.  
Availability: NTIS

HS-801 714

#### **SCHOOL BUS PASSENGER SEAT TESTING. FINAL REPORT**

Sled tests and analytical studies were conducted to evaluate the effectiveness of NHTSA's Notice of Proposed Rulemaking (NPRM) on school bus passenger seating and crash protection, in reducing the injury potential to the seated occupants in frontal impacts. The study parameters included seat back height and contours; number and size of the occupants; and impact velocity. The following observations, as limitation factors in the NPRM requirements, were indicated: proper phas-

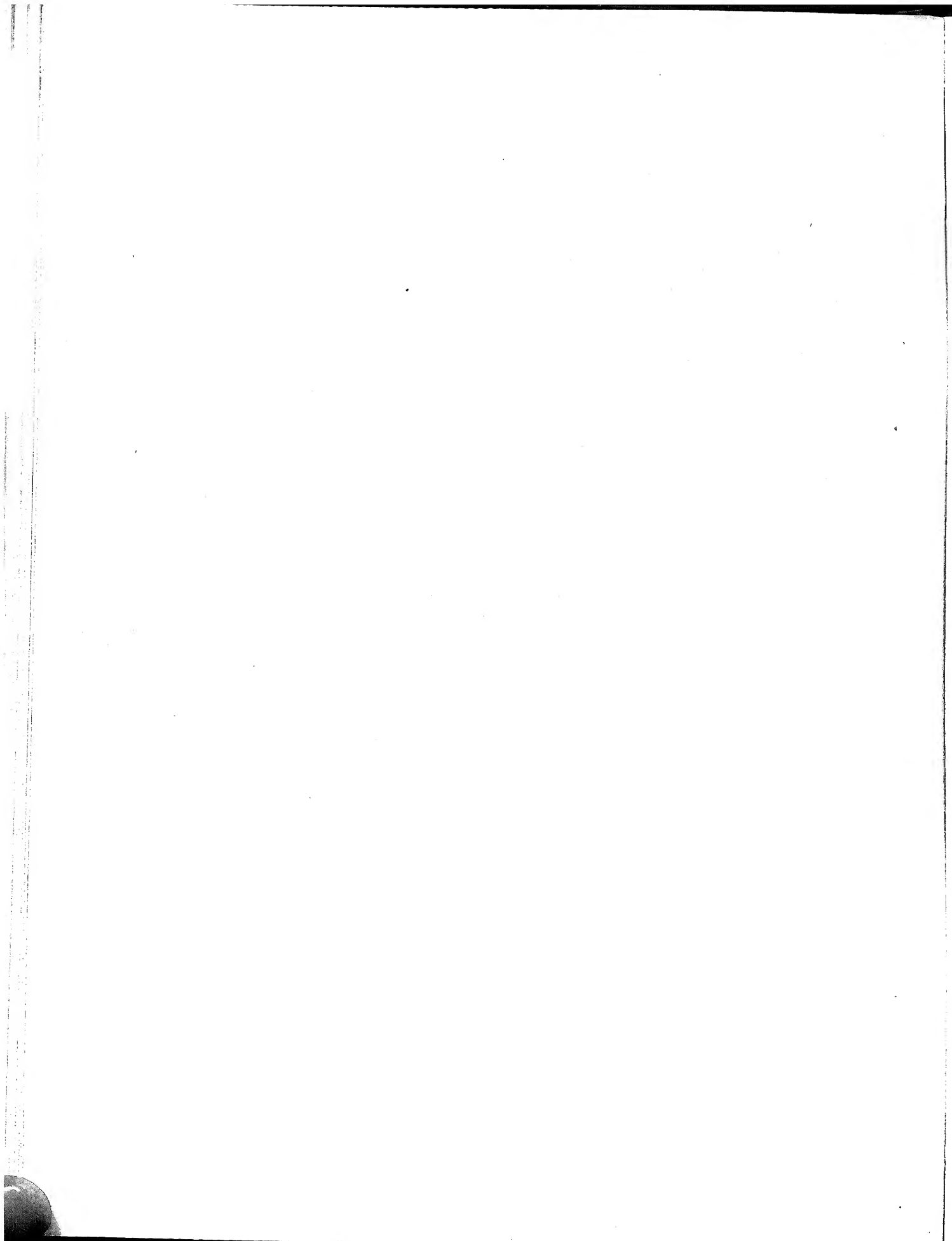
HSL 76-02

ing of passenger loads can minimize the tendency for passenger whipping; in adults, the knees impact first and slow down along with the bus; in children, the knees impact first, but since the feet are not on the floor, the knees contact area drops down, causing the head and chest to approach their impact areas without changing elevation; with proper load phasing the NPRM is effective at speeds up to 20 mph; the effects of seat back height were found to be not particularly significant in frontal impacts; the number and size of passengers impacting the back of a seat have an effect on the passenger trajectory and loads. AMF sled test simulations were performed, and passenger head, chest and femur load graphs are summarized in Appendix B. Metal to which strain gages were mounted, and a defective head neck interface on a child dummy are felt to be responsible for some erroneous data in several runs. Additional sled test data was compiled on developmental school bus seats, and charts are included in Appendix C. Logic flow charts and computer program listings used in generating simulation data are included as Appendix D.

by L. Adams  
AMF Advanced Systems Lab., 495 South Fairview Ave.,  
Goleta, Calif., 93017  
Contract DOT-HS-4-00969  
1975 ; 236p  
Rept. for Mar-Jul 1975. Includes, as appendices B and C, "Test Report on Sled Tests of Standard and Developmental School Bus Seats" and "Additional Sled Test Data on Developmental School Bus Seats" prepared by Minicars, Inc., Goleta, Calif.  
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LS-49848	HS-017 293	SAE-750096
LTR-ST.767	HS-017 421	SAE-750097
MTR-6700	HS-017 260	SAE-750098
MTR-6701	HS-017 271	SAE-750118
MTR-6702	HS-017 272	SAE-750119
	HS-017 273	SAE-750120
		HS-017 274
		HS-017 275
		HS-017 276
		HS-017 277
		HS-017 422
		HS-017 318
		HS-801 472
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		HS-017 278
		HS-017 408
		HS-017 326
		HS-017 393
		HS-017 322
		HS-017 283
		HS-017 259
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SAE-750121	HS-017 299	UM-HSRI-BI-74-4	HS-017 357
SAE-750123	HS-017 300	UM-HSRI-PF-75-6	HS-017 372
SAE-750124	HS-017 301	VAPC-A-7505-8	HS-017 280
SAE-750129	HS-017 302	VRI-7.1	HS-017 357
SAE-750130	HS-017 303	1/74	HS-017 233
SAE-750158	HS-017 304	10/74	HS-017 238
SAE-750159	HS-017 305	12/74	HS-017 239
SAE-750167	HS-017 306	13/74	HS-017 240
SAE-750169	HS-017 317	14/74	HS-017 241
SAE-750170	HS-017 315	19/74	HS-017 242
SAE-750171	HS-017 314	20/74	HS-017 243
SAE-750172	HS-017 313	21/74	HS-017 244
SAE-750173	HS-017 312	23/74	HS-017 245
SAE-750174	HS-017 311	24/74	HS-017 246
SAE-750175	HS-017 310	26/74	HS-017 248
SAE-750176	HS-017 309	27/74	HS-017 247
SAE-750177	HS-017 308	3/74	HS-017 234
SAE-750178	HS-017 307	36/74	HS-017 249
SAE-750179	HS-017 316	37/74	HS-017 250
SAE-750180	HS-017 333	38/74	HS-017 251
SAE-750181	HS-017 327	39/74	HS-017 252
SAE-750183	HS-017 320	4/74	HS-017 235
SAE-750187	HS-017 392	40/74	HS-017 253
SWRI-11-3075-Vol-3	HS-801 182	41/74	HS-017 254
TRRL-LR-669	HS-017 325	42/74	HS-017 255

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HS-017 256

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HS-017 401

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HS-017 402

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HS-017 258

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HS-017 400

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HS-017 403

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HS-017 399

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HS-017 236

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HS-017 237

# STATE PROGRAM ON ALCOHOL, CARBON MONOXIDE AND OTHER DRUGS AND THEIR RELATION TO HIGHWAY SAFETY

by

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Department of Toxicology

At the request of the State Legislature, the State Department of Toxicology has agreed to analyze the blood of all drivers involved in fatal motor vehicle accidents in Indiana. This report is limited to drivers who were themselves fatally injured.

Coroners send specimens to the Indiana State Police Laboratory for primary alcohol analysis which may be used in criminal or civil proceedings. The specimens are then delivered to the State Department of Toxicology where they are re-examined for alcohol, carbon monoxide and drugs. The results of these analyses are not available for criminal or civil litigation. The coroners are given the option of labeling the specimens for blood study only and sending them directly to the State Department of Toxicology, thus avoiding any possibility of the results being used in litigation. This is very rarely done.

This report covers the period July 1, 1974 to July 1, 1975. During this time 714 driver fatalities occurred in Indiana. Blood specimens from 416 (58%) of these were submitted by the coroners and are included in this report.

TABLE 1

Distribution of Blood Alcohol Concentrations In Drivers  
Involved In Fatal Automobile Accidents In Indiana  
During The Period July 1974-July 1975

Blood Alcohol*	Number of Drivers	Percent of Total	
0	192	46.2	59.9
0.001-0.049	34	8.2	
0.050-0.099	23	5.5	
0.100-0.199	87	20.9	40.1
0.200-0.299	68	16.4	
0.300-0.399	10	2.4	
0.400-0.499	1	0.2	
Above 0.499	1	0.2	
TOTAL	416	100	100

\* gram percent

Table 1 indicates the frequency of occurrence of various ethanol concentrations. Ethanol was found to be present in 54 percent of the specimens. Forty percent of the samples had ethanol concentrations that exceeded 0.10 percent, the level recognized in Indiana as prima facie evidence of driving under the influence of alcohol.

Occurrence of other volatile compounds is indicated in Table 2. One specimen contained a high concen-

TABLE 2

Occurrence of Acetone, Isopropanol and Methanol In The  
Blood of Drivers Involved In Fatal Accidents In Indiana  
During The Period July 1974-July 1975

Volatile Substance	Concentration*	Ethanol Concentration*
Isopropanol	0.104	
Methanol	0.024	
	0.025	
	0.083	
	0.100	
	0.152	0.139

\* Gram percent

tration of isopropanol. Inasmuch as this compound is commonly used to disinfect medical instruments and the skin, it is possible that it was introduced during treatment or autopsy. Methanol was found alone in four specimens and in combination with ethanol in one. The concentrations of methanol were not in the toxic range (not greater than 0.2 percent). Finding methanol in combination with ethanol is not surprising in view of its presence in certain alcoholic products such as wines and brandies. In addition, there are the possibilities of contamination of the blood with alcohol-based antiseptic solutions or direct consumption of methanol.

Barbiturates were found in 2 percent of the blood specimens (Table 3). In 62 percent of the samples in which barbiturate was found, ethanol was also

TABLE 3

Occurrence of Drugs In The Blood of Drivers Involved  
In Fatal Accidents In Indiana During The Period  
July 1974-July 1975

<i>Drug</i>	<i>Concentration</i>	<i>Ethanol</i>
Phenobarbital	0.6	
Phenobarbital	2.2	0.140
Phenobarbital	1.8	0.235
Phenobarbital	0.8	0.055
Phenobarbital	0.5	
Phenobarbital	0.5	0.130
Butabarbital	0.4	
Phenobarbital	0.6	0.247
Phenobarbital	0.4	

present. Phenobarbital or phenobarbital and butabarbital were the only barbiturates found in combination with ethanol. The concentrations of barbiturates found were in the range that would cause sedation in most individuals. While not necessarily causing impairment in isolation, the barbiturates may have interacted with the ethanol to cause a more profound impairment than that from the ethanol alone.

Carbon monoxide was measured in each sample. Carbon monoxide is thought to produce toxic symptoms in some individuals when 10 percent of the hemoglobin is in the form of carboxyhemoglobin. In 13.5 percent of the samples, carbon monoxide exceeded this concentration. Of these, 54 percent had ethanol concentration of 0.1 percent or more. In one case the carboxyhemoglobin fraction was 20.3 percent. This amount of carbon monoxide may have caused some impairment in driving ability and alertness. While it seems doubtful that combination of less than 20 percent of hemoglobin with carbon monoxide causes significant impairment in the drug-free individual,

the effects may have been significant in some cases in which other drugs were present.

Blood concentrations of carbon monoxide may be influenced by smoking habits, occupation, place of residence and other factors. It may be possible to correlate the frequency of use of alcohol and other drugs with numerous factors such as age, occupation and environment. Seventy-four percent of the drivers killed in motor vehicle accidents in Indiana during the period of this study were from rural areas. More specific information on the drivers is not available at this time.

The blood samples submitted for analysis were seldom clotted or severely decomposed. One sample appeared to contain aldehyde. Due to the possibility that this sample was contaminated with embalming fluid which might also contain high concentrations of alcohols, this sample was excluded from the study.

The volume of the specimens ranged from 1 to 30 milliliters. The sizes of the samples were adequate for the analyses for ethanol since only a fraction of a milliliter is required. However, screening methods for other drugs including amphetamines, barbiturates, tranquilizers, etc. often require 5 to 10 milliliters per test. Seven percent of the specimens submitted for this study were of insufficient size to allow complete analysis. Ideally, all samples should consist of 20 or more milliliters of blood.

NOTE—Methods: Ethanol, methanol, acetone and isopropanol were measured by gas chromatography. Carboxyhemoglobin concentrations were measured with a model IL 182 Co-Oximeter (Instrumentation Laboratories, Inc., Lexington, Mass.). Other drugs were detected by use of thin layer chromatography of solvent extracts of blood and confirmed by gas chromatography.

